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ABSTRACT

This curriculum guide is one of a series automotive service specialty publications that continues students' training in the automotive service trade by providing instruction in the engine performance specialty. It is based on the National Institute of Automotive Service Excellence task lists. Each of the 16 units includes some or all of the basic components of a unit of instruction: objective sheet, instructor's guide, information sheets, instructional supplement, assignment sheets, job sheets, written test, answers to assignment sheets and test, transparency masters, learning activity package (LAP) sheets, handouts, and other required media. The instructor's manual contains the following: curriculum and duty/task crosswalk; basic skills documentation matrix; suggested videos; one set per unit of instructor's guide, answers, and test code sheets; and instructional supplement that provides strategies for teaching basic skills. The isntructor's resource package includes one set per unit of LAP sheet and written test, handouts, transparency masters, and other required media. The student workbook consists of objective sheets, information sheets, assignment sheets, and job sheets. Unit topics are as follows: understanding engine fundamentals; servicing starting and charging systems; servicing engine cooling systems; servicing exhaust systems; evaluating engine condition; understanding engine computer controls; and servicing the following systems--ignition, fuel delivery, fuel injection, turbocharger, positive crankcase ventilation, exhaust gas recirculation, air injection, heated air induction, manifold heat control, and fuel vapor control systems. (YLB)

ED 385 679

Automotive Service Series

Engine Performance Specialist

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CIMC

Teacher Edition

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Oklahoma Department of
Vocational and Technical Education
1500 West Seventh Avenue
Stillwater, OK 74074-4364

TI1234

Engine Performance Specialist

Instructor's Manual

Upfront

Crosswalk

Suggested Videos

Instructor's Guide

Answers

Test Code Sheets

Instructional Supplement

Developed by the
Curriculum and Instructional Materials Center
for the Division of **Trade and Industrial Education**
Oklahoma Department of Vocational and Technical Education

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Curriculum and Instructional Materials Center

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Instructional Supplement 1

One set per unit of the following components:

- Instructor's Guide
- Answers
- Test Code Sheets

Instructional Supplement (one set for all units)

Instructor's Resource Package

One set per unit of the following components:

- LAP Sheet
- Transparency Masters
- Written Test
- Other required media

Student Workbook

One set per unit of Objective Sheets, Information Sheets, Assignment Sheets, and Job Sheets for the following units:

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FOREWORD

This is one in a series of eight automotive service specialty publications that is based on the National Institute of Automotive Service Excellence (ASE) task list. This series provides instruction for all high priority competencies established by ASE and will contribute greatly to an auto service technology program's ability to meet the requirements of a nationally certified training school.

The ASE competencies are developed by industry to meet the industry's need for quality technicians. This curriculum addresses that need. The industry and education committee that has validated the technical accuracy of this material is commended for outstanding service and commitment to the quality of these instructional units. The instructors and students who use this material are challenged to have the same commitment to excellence.

We trust that this is instructional material will meet students' needs as they prepare for careers in engine performance service.

Dr. Roy Peters, Jr.
State Director
Oklahoma Department of Vocational
and Technical Education

Ivan Armstrong
State Supervisor
Trade and Industrial Education
Oklahoma Department of Vocational
and Technical Education

PREFACE

The purpose of *Engine Performance Specialist* is to continue the students' training in the automotive service trade by providing instruction in this specialty area. This publication is one in a series of eight publications for automotive specialty areas. Other area included in this series are brakes, steering and suspension, engine repair, electrical, heating and air conditioning, automatic transmission/transaxle, and manual drivetrain and axles.

Instructors are faced with the challenge of teaching the skills and related information necessary for their students to become the highly qualified automotive service specialists that are in demand today. This curriculum guide is designed to help instructors meet this challenge. The objectives in this curriculum are based on those National Institute of Automotive Service Excellence (ASE) tasks that are required of an Automotive Engine Performance Specialist.

Lynnette Johnson
Instructional Development Specialist
Curriculum and Instructional
Materials Center

ACKNOWLEDGMENTS

The Curriculum and Instructional Materials Center (CIMC) extends its appreciation to those individuals who played important roles in the development of *Engine Performance Specialist*.

Special appreciation is extended to those who so generously contributed their substantial expertise, talents, and time to serve on the *Engine Performance Specialist* curriculum validating committee.

Jon Priebe Auto Clinic Oklahoma City, OK	Willard Carter Kiamichi AVTS Durant, OK

Orville Manuel
District Supervisor, S. W.
Trade and Industrial Education Division
Oklahoma Department of Vocational and Technical Education

We want to thank the state director, Dr. Roy Peters Jr., and the assistant state director, Dr. Charles O. Hopkins, for their continued support throughout this project. The state supervisor for Trade and Industrial Education, Ivan Armstrong, also deserves special recognition and thanks.

Special recognition is due to the excellent staff of writers who wrote the curriculum: Linda Moore, Terri Mink, Suzanna Laurent, Jennifer Owen, and Andrea Collin.

Special recognition is offered to the individuals who functioned in important roles throughout the development of the *Engine Performance Specialist* curriculum: Brenna Tillman and Charlotte Tarkington who did the word processing; Judith Armstrong who did the copyediting; Suzanne Perry who secured the permissions for the illustrations; Allie Smith who identified the Basic Skills; Billie Frazier who helped write the Instructional Supplement; Bob Davis and his excellent staff in the Art Department; Danny Darrow and Diane Ensign and their staffs at the ODVTE Print Shop; and Terri Tomson, CIMC secretary, for her invaluable help throughout production.

A very special acknowledgement goes to Jon Priebe for his eleventh hour technical assistance and valuable experience in completing the project and to Howard Johnson, automotive instructor at Francis Tuttle Vo-Tech Center, for his gracious help and sharing the fruits of his extensive knowledge and skills.

And finally, a very special acknowledgement goes to Chuck Pendergast, the technical advisor for this project, without whose expert collaboration, advice, support, review, and encouragement this curriculum would not have been possible.

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Instructional Development Specialist
Curriculum and Instructional Materials Center
Oklahoma Department of Vocational and Technical Education

USE OF THIS PUBLICATION

INSTRUCTIONAL UNIT

Each unit of instruction is based on the performance needed for successful employment in an occupational area. *Engine Performance Specialist* contains 16 units of instruction. A complete unit will contain most or all of the following components: Objective Sheet, Instructor's Guide, Information Sheet, Instructional Supplement, Assignment Sheet, Job Sheet (and Skill Test Record), Written Test, Answers (to Assignment Sheets and Written Test), Transparency Masters, Learning Activity Package (LAP) Sheet, Handouts, and other required media. These components are organized within three packages, as follows:

Instructor's Manual

- Upfront pages (title page, copyright page, table of contents, foreword, preface, acknowledgments, measuring student performance gains, required criteria for a competency-based education program, and corrections and suggestions)
- Curriculum and Duty/Task Crosswalk (as appropriate)
- Basic Skills Matrix
- One set per unit of:
    - Instructor's Guide
    - Answers
    - Test Code Sheets
- Instructional Supplement (one set for all of the basic skills enablers appearing in the book)

Instructor's Resource Package

- One set per unit of:
    - LAP Sheet
    - Written Test

☑ **NOTE:** The two components listed above may be photocopied by the instructor.

- Handouts (as appropriate)
- Transparency Masters (as appropriate)
- Other required media (as appropriate)

Student Workbook

- Objective Sheets
- Information Sheets
- Assignment Sheets
- Job Sheets

Instructor's materials include the *Instructor's Manual*, the *Instructor's Resource Package*, and the *Student Workbook*.

Unit components are tied to measurable and observable learning outcomes. Instructors are encouraged to supplement unit components with other resources to make units as responsive to local conditions and student needs as possible.

Most units of instruction are designed for use in more than one lesson or class period. Instructors should determine the following for each unit:

- amount of material that can be covered in each class period;
- skills that must be demonstrated;
- supplies and equipment needed;
- amount of class time needed for demonstrations;
- amount of class time needed for student practice;
- supplementary materials to be ordered; and
- resource persons who must be contacted.

Objective Sheet (Student Workbook)

The Objective Sheet summarizes each unit for the student and the instructor. The Objective Sheet includes the following sections:

Introduction – This section introduces students to the unit topic and its importance to them. The Introduction also relates the unit to students' experiences and their "need to know"; it helps capture their interest and focus their attention on the specific topic.

Prerequisites – This section is included if any of the units in the book have prerequisites. A prerequisite may be one or more units from the same book or from other books which must be completed before beginning the unit. (If no prerequisites exist for any of the units in the book, this section is omitted.)

Focus Assignments – Each unit has two focus assignments: Prereading and Writing. The prereading assignment requires the student to read appropriate sections from unit references, from the *Instructor's Resource Package*, or from the student's textbook. The prereading assignment leads into the writing assignment, which assigns students a short written activity based on the prereading assignment. Because the focus assignments help promote the use of basic skills, they include appropriate basic skill icons and enablers. (Activities for the basic skills associated with the focus assignments are included in the Instructional Supplement in the Instructor's Manual.)

Unit Objective – The unit objective states the overall goal of the unit. It identifies what the student will be able to do after successfully completing the unit, as well as the standards used to measure student performance.

Specific Objectives – The specific objectives outline the teaching sequence of the competencies required to reach the unit objective.

The specific objectives on the Objective Sheet should be emphasized to all students at the start of each unit and throughout the teaching/learning process. This will help answer student questions about performance requirements for each unit. Specific objectives can also assist instructors in determining teaching strategies and instructional methods. Instructors should prepare for each unit by deciding how each objective could best be taught.

Instructors should modify, delete, or add objectives to meet the needs of students and the community. When objectives are added, the instructor should remember to provide the needed Information, Assignment and/or Job Sheets, and criterion-referenced test items to cover the new objectives.

Information Sheet (Student Workbook)

The Information Sheet provides the "must know" content essential for meeting the cognitive objectives in the unit. Information is usually presented in print on the Information Sheet, but may also be presented in other formats, if appropriate, such as on videotape, software, or other media. (Additional formats for presenting the Information Sheet objectives allow this component to be interactive.)

Many objectives on the Information Sheet begin with a "Words You Should Know" section. This boxed item identifies terms relating to the objective, and gives a definition for each. Terms in the "Words You Should Know" boxes are tested only indirectly with the objective information and not on the Written Test as a matching exercise.

The Information Sheet may include clarifying NOTES and EXAMPLES as needed. In the left column, students and instructors are reminded of the optional and/or required activities and resources available for a particular objective.

Students should read the Information Sheet for each unit before it is discussed in class. Space is provided in the margins for both students and instructors to add notes that clarify and/or expand upon the information presented.

Assignment Sheets (Student Workbook)

The Assignment Sheets address the learning levels at or above the application level of Bloom's taxonomy. They allow students to perform non-psychomotor activities related to occupational tasks. Assignment Sheets also provide students with an opportunity to use higher-order thinking skills, such as problem-solving, synthesizing, analyzing, and evaluating. In addition, they may provide opportunities for cooperative learning and more detailed oral/written communication activities.

Assignment Sheet activities can be "paper and pencil" activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate.

Job Sheets (Student Workbook)

Job Sheets give students step-by-step procedures for performing manipulative or psychomotor occupational tasks or jobs. The Job Sheet also functions as a Skill Test Record, facilitating the instructor's evaluation of each student's performance. Both the process and the end product are evaluated. Diagrams, illustrations, and photographs are included, as needed, to assist students in completing the job.

Individual Job Sheets may include various warnings written to conform to the latest specifications of the American National Standards Institute (ANSI). DANGER is used if the situation *will* lead to death or serious injury if not avoided; WARNING is used if the situation *could* lead to death or serious injury if not avoided; CAUTION is used if the situation could lead to minor or moderate injury; NOTICE is used if the situation could cause property damage only; and IMPORTANT is used to refer to operating or maintenance tips. Each type of warning appears on the Job Sheet with an ANSI symbol.

The instructor should demonstrate the procedure outlined in each Job Sheet. Instructors may also have to localize specific procedures.

Instructor's Guide (Instructor's Manual)

The Instructor's Guide leads instructors step by step, objective by objective through the unit. It recommends instructional strategies for the focus assignments and for each of the specific objectives. Resources and activities are labeled "R" for "required" or "O" for "optional." Optional and required resources (publications, videos, computer software, and other media) are listed, as well as unit references. These resources can be used to supplement the instructor's knowledge of the subject area and to help students with particular interests or occupational objectives. In addition, the Instructor's Guide provides guidelines for evaluating student performance.

Instructors should study the Instructor's Guide before introducing the unit, allowing enough time to obtain supplemental materials, prepare audiovisual materials, and to contact outside resource persons. Specific tasks of the instructor will vary with each unit.

Answers (Instructor's Manual)

This component lists the answers to all of the Assignment Sheets and the Written Test questions.

Test Code Sheet (Instructor's Manual)

The Test Code Sheet matches Written Test questions to objectives. Basic skills codes are listed in chart format for each question. Each unit has a Test Code Sheet. For more information, see the CIMC publication *Measuring Learning & Competency Gains: The Pretest/Posttest Approach.*

Instructional Supplement (Instructor's Manual)

The Instructional Supplement provides the instructor with strategies for teaching the basic skills identified on the focus assignments, Assignment Sheets, and Job Sheets. An Instructional Supplement has been developed for each basic skill identified.

LAP Sheet (Instructor's Resource Package)

The LAP (Learning Activity Package) Sheet for each unit allows the instructor to individualize instruction for some or all students. The LAP Sheet guides the student through each unit step by step, ensuring that the student receives the necessary instruction.

Transparency Masters (Instructor's Resource Package)

Transparency Masters are provided so that instructors can make transparencies to accompany specific units. Transparencies allow students to *see* as well as hear the information being presented, thus reinforcing the learning process. They also direct attention to the topic under discussion. Transparencies should be made from the Transparency Masters and placed where they will be readily available when needed. Transparencies should be left on the screen only when the related topics are under discussion.

A small reproduction of each Transparency Master also appears in the appropriate unit in the Student Workbook, at the location where the information is referenced, such as a figure on the Information Sheet.

Written Test (Instructor's Resource Package)

The Written Test provides criterion-referenced evaluation of the specific objectives from the Information Sheet (Assignment Sheet and Job Sheet objectives are not evaluated by the Written Test). If instructors have added, deleted, or modified any objectives, appropriate changes should be made to the Written Test as well.

The Written Test serves as both a pretest and a post test. In order to measure and document student competency gains as required by the latest Carl Perkins regulations, and as outlined in the Oklahoma-developed system of standards and measures, it is *essential* that the same test be used as a pretest and as a post test. If instructors choose to use tests other than the Written Test, they should make sure that the same instrument is used for each activity – pre- and post test.

The Written Test may be photocopied for classroom use, or additional copies may be ordered from the CIMC by calling 1-800-654-4502, or (in Oklahoma) 1-800-522-5810, ext. 589.

A detailed explanation of the Oklahoma plan for standards and measures and the Carl Perkins requirements is included in the CIMC publication *Measuring Learning & Competency Gains: The Pretest/Posttest Approach.* This booklet – and accompanying software to assist in calculating and recording student gains – are available to Oklahoma instructors through their school's vocational testing liaison.

To further assist instructors, the CIMC has developed Test Code Sheets for each Written Test in its more recent publications, including this one. (These sheets are explained in detail in the publication mentioned above.) The Test Code Sheets assist in verifying that the Written Test is a valid instrument for measuring student learning and competency gains.

COMPETENCY PROFILES

A Competency Profile is available from the CIMC. Competency Profiles document student performance. Each profile lists the specific competencies covered in the book, and provides space for recording the student's level of performance on each competency.

PAGE NUMBERING

Each unit and each page in a CIMC publication has a number, shown in Arabic numerals. The page number gives the package title, the book title, the component name, the unit number, and the page number within the unit. For example, the page number for page 1 in Unit 6 of the *Student Workbook* would appear as follows:

> STUDENT WORKBOOK – Engine Performance Specialist
> OBJECTIVE SHEET · **CIMC** · 6 · 1

METHODS OF DISSEMINATING MATERIAL

For best results, provide each student with a copy of the Student Workbook. Students should be allowed to keep their Workbooks at the end of the course or training program.

TEACHING METHODS

Keeping students motivated is a challenge. Supplement each unit with current information, personal experiences, and other information. In a group setting, prepare for each unit by determining the best way to teach each objective, and allow for student input. For individualized instruction, provide opportunities for the student to become involved in planning and being responsible for his or her own education.

BASIC SKILLS IN CURRICULUM

The CIMC has always been mindful of the importance of reinforcement (and sometimes remediation) of students' academic skills as they progress through vocational training, and has always included activities in its materials to enhance and promote use of these skills.

Recent state and federal legislation mandates vigorous basic skills development in vocational education in the wake of demands by industry that workers *must* be academically, as well as technically, competent, given the nature of the highly complex work place. In response, the CIMC has taken the following steps to document that, indeed, the instructional materials *do* combine academic skills training with the vocational training. In addition, concerted efforts have been made to "beef up," or enhance the basic skills instruction already present. Following is a brief description of those processes:

Basic Skills Icons and Enablers

To assist teachers and students in identifying activities that promote basic skills development, the CIMC has implemented a marking system that uses simple graphic symbols, or icons, and a list of specific tasks, or enablers, to identify the basic skill or skills that are called for in each Job or Assignment Sheet, and in focus assignments.

Each of the nine broad skills areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, creative thinking and problem solving, employability, and social studies—is represented by the icon presented below.

Reading
Science
Creative Thinking/ Problem Solving
Writing
Oral Communication
Employability
Math
Interpersonal or Relating
Social Studies

When an activity involving one of these basic skills is identified, the corresponding icon is placed in the left-hand margin of the Job or Assignment Sheet. The basic skills training is further defined by retrieving the specific, or enabling, skill that is required by consulting a list of over two hundred and fifty enablers that has been compiled and grouped with each general basic skill. This enabling skill is placed directly below the icon.

As an example, an exercise that requires a student to conduct library research would make necessary the use of specific reading comprehension and research and reference skills. The basic skills that the exercise promotes would be depicted in the left-hand margin as follows:

ASSIGNMENT SHEET — *PLANNING LIVING SPACE FOR HUMAN NEEDS* — 1

Name ______________________________ Score __________

OBJECTIVE 10 — **Define personal territory.**

INSTRUCTIONS

- As discussed in Objective 1, each person has an invisible "space bubble" or comfort zone. A comfort zone is the space between oneself and others that brings a feeling of well-being. When one's comfort zone is crowded or invaded, discomfort often results. Therefore, personal territory needs should be a prime consideration when planning living space.
- For each of the following situations, draw your estimated comfort zone around the figures provided.
- Indicate how many inches from your body the comfort zone extends.
- Consider how that comfort zone changes in different situations. Answer the questions that follow.

Reading Comprehension
- Gain factual information

Functional Reading
- Follow written instructions
- Use content area vocabulary

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Basic Skills Documentation Matrix

Another component of the CIMC basic skills instructional plan is the "Basic Skills Documentation Matrix." The matrix graphically summarizes the basic skills training included in the vocational program, unit by unit. It should be helpful to teachers in planning their instruction, and to administrators as documentation that basic skills **are** being addressed during the vocational training.

The matrix for this publication is included as an 8½" by 11" foldout in this *Instructor's Manual.*

Matrices have been developed for most CIMC publications. For more information on those available for other programs, call the CIMC at 1-800-654-4502.

Instructional Supplement

The supplement is a tool for the instructor to use in helping students apply the basic skills in Assignment Sheets and Job Sheets. Some supplements are appropriate for use with all students; some are for use only with those students who do not understand the academic skills called for in the exercise.

MEASURING STUDENT PERFORMANCE GAINS

When you examine this book, you will notice that separate written pretests are no longer included in the units of instruction. Each CIMC unit now contains only a single Written Test. This test should be used as **both** pretest and post test by giving it once before students start a unit and again when they have completed the unit.

The reason for using a single instrument as both pretest and post test is so that direct comparison of each student's competencies before and after instruction can be made accurately. This comparison enables precise calculation, documentation, and evaluation of student **performance gains**.

Accurate performance gains analysis is an important requirement of the new Carl Perkins legislation for vocational education. Teachers can make an important contribution to the performance accountability mandated by the new federal legislation by carrying out accurate performance gains analysis for their students, and making this data available to students, parents, and administrators.

This analysis is easy to do and requires only simple calculations and record keeping. Detailed information regarding performance gains analysis is contained in the CIMC publication, *Measuring Learning & Competency Gains: The Pretest/Posttest Approach*. In addition, the CIMC has developed a computer program, CARL, which will perform all necessary calculations and will print out a record form of all information required for gain score analysis. Copies of CARL and the publication are available through your local testing liaison (in Oklahoma), or from the CIMC at 1-800-654-4502.

REQUIRED CRITERIA FOR A COMPETENCY-BASED EDUCATION PROGRAM

Criterion	**Discussion**	**CIMC component meeting criterion**
1. Instruction is based on clearly-stated learning objectives that are: a) observable and measurable, and b) communicated in writing to students before instruction begins.	Learning objectives drive CBE. Objectives are the "competencies" that learners must achieve. Each objective must clearly state what *learners* must *do* to demonstrate acquired skill or knowledge. Verbs in learning objectives are active and precise, stating the exact performance expected of learners. The objectives should also specify the standard or level of performance required. Objectives can be at any level of Bloom's Taxonomy and can include the cognitive, psychomotor, and affective domains. Higher-order cognitive skills should be included.	Objective Sheet
2. Instruction is aligned with the stated learning objectives	In CBE, the objectives specify what is taught. "Content" should relate to one or more objectives. The curriculum should cover all objectives with relevant information.	Information Sheet
3. There is a student evaluation system that is: a) criterion-referenced, and b) aligned to the learning objectives and the curriculum.	In CBE, the aim is to bring the performance of *all* learners up to a pre-defined standards and competencies. Learners work on each competency until they achieve "mastery"; the evaluation system should test and record this mastery. Learners can restudy and retest as often as needed. Specific remediation activities should also be available to learners when needed. The evaluation system focuses on what each student has achieved, not on what the instructor has "taught." The "constant" in CBE is student performance; the "variables" are time and resources. (This differs from traditional systems where learners get one chance at mastery; some succeed and some fail. In such systems, time and resources are constant and student achievement is variable.) If an evaluation is criterion-referenced, successful learner performance is defined by (or *referenced* to) mastery of pre-set objectives and standards (or *criteria*): there must be a careful match (or *alignment*) between what the student should master (objectives), what is taught (curriculum), and what is tested. Objectives, curriculum, and evaluation system must all match.	Written Test and Job Sheet/Skill Test

Criterion	Discussion	CIMC component meeting criterion
4. There is an observable management system of cognitive skill practice that provides for, promotes, and documents mastery learning.	For both cognitive and psychomotor skills, a CBE program must have a system of maintaining records of which skills and activities each learner has completed, which ones are in progress, and which ones have not yet been completed. Completion means "mastery"; no skill is completed until the learner has achieved the mastery level. The record system should promote feedback on student skill attainment to *both* instructor and learners, provide for remediation as needed, and encourage reevaluation of learner performance until mastery is achieved. Appropriate remediation strategies often should consider learning styles and other individual differences among learners. Learners should work on skills and activities until they achieve mastery. They should not be "passed on" without mastery. While learners may move ahead and work on other skills (i.e those for which all prerequisite skills have been mastered or those without prerequisites), work should also continue on the skills still requiring mastery. Students should not attempt higher-order skills until all prerequisite skills are mastered.	Assignment Sheet
5. There is an observable management system of psychomotor skill practice that provides for, promotes, and documents mastery learning.		Job Sheet/Skill Test
6. Skill mastery records are maintained for each learner, and learners have access to and make use of these records to monitor their skill acquisition.	Records should clearly indicate the skills each learner has mastered. One such record should profile or list the competencies that have been mastered and those to be mastered. Other performance indicators can be added and kept in a portfolio for each learner. Learners should have ready access to their portfolios to monitor their own progress in skill mastery and competency attainment.	Competency Profile

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with accurate and effective materials. Although the CIMC strives to maintain the highest standards of development and production, oversights sometimes do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. To do this, please identify the page(s) affected and write any comments to clarify the error or suggestion. Use the spaces below. Then, simply fold (bottom of page *upward*, top *downward*), secure, and mail.

This information will be used to correct the publication before the materials are reprinted. To ensure that the material is updated on a timely basis, notify the CIMC of necessary corrections as soon as possible after discovering the error.

2 Fold downward

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ASE - CIMC CROSSWALK

ENGINE PERFORMANCE SPECIALIST

The following table shows the correlation between the specific tasks on the task list prepared by the National Institute of Automotive Service Excellence (ASE) and the instructional components in this CIMC (Curriculum and Instructional Materials Center) curriculum. This curriculum was prepared from the ASE task list copyrighted in 1993.

NO.	ASE TASK	CIMC UNIT/ COMPONENT
A	**GENERAL ENGINE DIAGNOSIS**	
A-1	Verify driver's complaint and/or road test vehicle; determine needed repairs.	Unit 5, Ass. Sheet 4
A-2	Inspect engine assembly for fuel, oil, coolant, and other leaks; determine needed repairs.	Unit 5, Job Sheet 5
A-3	Diagnose the cause of unusual engine noise and/or vibration problem; determine needed repairs.	Unit 5, Ass. Sheet 4
A-4	Diagnose the cause of unusual exhaust color, odor, and sound; determine needed repairs.	Unit 5, Ass. Sheet 2
A-5	Perform engine vacuum/boost (manifold absolute pressure) tests; determine needed repairs.	Unit 5, Job Sheet 6 & Ass. Sheet 3
A-6	Perform cylinder power balance test; determine needed repairs.	Unit 5, Job Sheet 7
A-7	Perform cylinder compression test; determine needed repairs.	Unit 5, Job Sheet 3 & Ass. Sheet 1
A-8	Perform cylinder leakage test; determine needed repairs.	Unit 5, Job Sheet 4
A-9	Diagnose engine mechanical, electrical, and fuel problems with an oscilloscope and/or engine analyzer; determine needed repairs.	Unit 6, Job Sheet 9, Unit 7, Ass. Sheet
A-10	Inspect and adjust exhaust gas analyzer, inspect vehicle's exhaust system, obtain exhaust gas readings.	Unit 5 Job Sheet 8

A-11	Diagnose engine mechanical, ignition, fuel, and emissions control problems with an exhaust gas analyzer; determine needed repairs.	Unit 16, Ass. Sheet.
A-12	Perform analytic/diagnostic procedures on vehicles with on-board or self-diagnostic type computer systems; determine needed repairs.	Unit 6, Job Sheet, & many Job Sheets
A-13	Inspect, test, adjust, and replace sensor and actuator components and circuits of electronic/ computer-controlled systems.	In many objectives
B	**IGNITION SYSTEM DIAGNOSIS & REPAIR**	
B-1	Diagnose no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, and poor mileage problems on vehicles with point type ignition systems; determine needed repairs.	Unit 7, Ass. Sheet
B-2	Diagnose no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, and poor mileage problems on vehicles with electronic ignition systems; determine needed repairs.	Unit 7, Ass. Sheet
B-3	Inspect, test, repair, or replace ignition primary circuit and components.	Unit 7, Job Sheet 1
B-4	Inspect, test, and service distributor including drives, shaft, bushings, cam, breaker plate, and advance/retard (vacuum, mechanical, or electrical) units.	Unit 7, Job Sheet 10
B-5	Inspect, test, adjust, service, repair, or replace ignition points and condenser.	Unit 7, Job Sheet 2
B-6	Inspect, test, service, repair, or replace ignition system secondary circuit wiring and components.	Unit 7, Job Sheet 3
B-7	Inspect, test, and replace ignition coil(s).	Unit 7, Job Sheet 4
B-8	Check and adjust ignition system timing and timing advance/retard.	Unit 7, Job Sheet 8
B-9	Inspect, test, and replace electronic ignition wiring harness and connectors.	Unit 7, Job Sheet 5
B-10	Inspect, test, and replace electronic ignition system pick-up sensor or triggering devices.	Unit 7, Job Sheet 6
B-11	Inspect, test, and replace electronic ignition system control unit (module).	Unit 7, Job Sheet 11

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C	**FUEL, AIR INDUCTION, AND EXHAUST SYSTEMS DIAGNOSIS AND REPAIR**	
C-1	Diagnose hot or cold no-starting, hard starting, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, and dieseling problems on vehicles with injector-type fuel systems; determine needed repairs.	Unit 9, Ass. Sheet
C-2	Inspect fuel tank, tank filter, and gas cap; inspect and replace fuel lines, fittings, and hoses; check fuel for contaminants and quality.	Unit 8, Job Sheet 5
C-3	Inspect, test, and replace mechanical and electrical fuel pumps and pump control systems; inspect, service, and replace fuel filters.	Unit 8, Job Sheet 2
C-4	Inspect, test, and repair or replace fuel pressure regulation system and components of a fuel injection system.	Unit 9, Job Sheet 4
C-5	Inspect, test, adjust and repair or replace fuel injection cold enrichment systems.	Unit 9, Job Sheet 6
C-6	Inspect, test, adjust, and replace fuel injection acceleration enrichment system and components.	Unit 9, Job Sheet 7
C-7	Inspect, test and replace fuel injection deceleration fuel reduction or shut off system and components.	Unit 9, Job Sheet 9
C-8	Remove, clean, and replace fuel injection throttle body and adjust related linkages.	Unit 9, Job Sheet 11
C-9	Inspect, test, clean, and replace fuel injectors.	Unit 9, Job Sheets 10 & 11
C-10	Inspect, service, and repair or replace air filtration system components.	Unit 8, Job Sheet 3
C-11	Inspect, clean, or replace throttle body mounting plates, fuel injection air induction system, intake manifold, and gaskets.	Unit 9, Job Sheet 11
C-12	Inspect, test, clean, adjust, and replace components of fuel injection closed-loop fuel control systems.	Unit 9, Job Sheet 1
C-13	Remove, clean, inspect/test, and repair or replace vacuum and electrical components and connections of fuel injection systems.	Unit 9, Job Sheet 3

C-14	Inspect, service, and replace exhaust manifold, exhaust pipes, mufflers, resonators, tail pipes, and heat shields.	Unit 4, Job Sheets 2 & 3
C-15	Test the operation of turbocharger/supercharger systems; determine needed repairs.	Unit 10, Job Sheets 1 & 3
C-16	Remove, clean, inspect, and repair or replace turbocharger/supercharger system components.	Unit 10, Job Sheets 2 & 4
C-17	Identify the causes of turbocharger/supercharger failure; determine needed repairs.	Unit 10, Ass. Sheets 1 & 2
D	**EMISSIONS CONTROL SYSTEMS DIAGNOSIS AND REPAIR**	
1	**Positive Crankcase Ventilation**	
D-1-1	Test the operation of positive crankcase ventilation (PCV) systems.	Unit 11, Job Sheet 1
D-1-2	Inspect, service, and replace positive crankcase ventilation (PCV) filter/breather cap, valve, tubes, orifices, and hoses.	Unit 11, Job Sheet 2
2	**Spark Timing Controls**	
D-2-1	Test the operation of spark timing control systems.	Unit 7, Job Sheet 7
D-2-2	Inspect, test, repair, and replace electrical/electronic components and circuits of spark timing control systems.	Unit 7, Job Sheet 9
D-2-3	Inspect, test, repair, and replace thermal, mechanical, or vacuum components and hoses of spark timing control systems.	Unit 7, Job Sheet 8
3	**Idle and Deceleration Speed Controls**	
D-3-1	Test the operation of idle speed control systems.	Unit 9, Job Sheet 1
D-3-2	Inspect, test, adjust, and replace sensors, solenoids, vacuum valves, motors, switches, wiring, and hoses of idle speed control systems.	Unit 9, Job Sheet 2
D-3-3	Test the operation of deceleration control systems.	Unit 9, Job Sheet 8

D-3-4	Inspect, test, adjust, and replace electrical components, circuits, vacuum components, and hoses of deceleration control systems.	Unit 9, Job Sheet 9
4	**Exhaust Gas Recirculation**	
D-4-1	Test the operation of exhaust gas recirculation (EGR) systems.	Unit 12, Job Sheet 1
D-4-2	Inspect, test, repair, and replace valve, valve manifold, and exhaust passages of exhaust gas recirculation (EGR) systems.	Unit 12, Job Sheet 4
D-4-3	Inspect, test, repair, and replace vacuum/pressure controls, filters, and hoses of exhaust gas recirculation (EGR) systems.	Unit 12, Job Sheet 3
D-4-4	Inspect, test, repair, and replace electrical/electronic sensors, controls and wiring of exhaust gas recirculation (EGR) systems.	Unit 12, Job Sheet 2
5	**Exhaust Gas Treatment**	
D-5-1	Test the operation of pump-type air injection systems.	Unit 13, Job Sheet 6
D-5-2	Inspect, test, service, and replace pump, pressure relief valve, filter, pulley, and belt of pump-type air injection systems.	Unit 13, Job Sheet 3
D-5-3	Inspect, test, and replace vacuum-operated air control valves and vacuum hoses of pump-type air injection systems.	Unit 13, Job Sheet 4
D-5-4	Inspect and replace electrical/electronic-operated components and circuits of pump-type air injection systems.	Unit 13, Job Sheet 5
D-5-5	Inspect, service, and replace hoses, check valves, air manifolds, and nozzles of pump-type air injection systems.	Unit 13, Job Sheets 1 & 2
D-5-6	Test the operation of exhaust pulse-type air injection systems.	Unit 13, Job Sheet 6
D-5-7	Inspect, test, and replace pulse air valve(s), filters, silencers, and hoses of exhaust pulse-type air injection systems.	Unit 13, Job Sheets 1 & 2
D-5-8	Inspect, test, service, and replace converter catalyst or converter(s) of catalytic converter systems.	Unit 4, Job Sheet 4
6	**Inlet Air Temperature Controls**	

D-6-1	Test the operation of inlet air temperature control systems.	Unit 14, Job Sheet 1
D-6-2	Inspect, test, and replace sensors, diaphragm, and hoses of inlet air temperature control systems.	Unit 14, Job Sheet 3
D-6-3	Inspect, test, and replace heat stove shroud, hot air pipe, and damper of inlet air temperature control systems.	Unit 14, Job Sheet 2
7	**Intake Manifold Temperature Controls**	
D-7-1	Test the operation of electrical/vacuum/coolant-type manifold temperature control systems.	Unit 15, Job Sheet 2
D-7-2	Inspect, test, repair, or replace components of electrical/vacuum/coolant-type manifold temperature control systems.	Unit 15, Job Sheet 1
D-7-3	Inspect, service, and replace manifold temperature control (heat riser) valves.	Unit 15, Job Sheet 3
8	**Fuel Vapor Controls**	
D-8-1	Test the operation of fuel vapor control systems.	Unit 16, Job Sheet 1
D-8-2	Inspect and replace fuel tank cap, liquid/vapor separator, liquid check valve, lines, and hoses of fuel vapor control systems.	Unit 16, Job Sheet 3
D-8-3	Inspect, service, and replace canister, filter, and purge lines of fuel vapor control systems.	Unit 16, Job Sheet 3
D-8-4	Inspect, test, and replace thermal, vacuum, and electrical controls of fuel vapor control systems.	Unit 16, Job Sheet 2
E	**ENGINE RELATED SERVICE**	
E-1	Adjust valves on engines with mechanical or hydraulic lifters.	Unit 5, Job Sheet 2
E-2	Verify correct valve timing; determine needed repairs.	Unit 5, Job Sheet 1
E-3	Verify engine operating temperature; determine needed repairs.	Unit 9, Job Sheet 5
E-4	Perform cooling system pressure tests; check coolant; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; determine needed repairs.	Unit 3, Job Sheets 1 & 2

E-5	Inspect, test, and replace thermostat, by-pass, and housing.	Unit 3, Job Sheet 3
E-6	Inspect, test, and replace mechanical/electrical fans, fan clutch, fan shroud/ducting, and fan control devices.	Unit 3, Job Sheet 4
F	**ENGINE ELECTRICAL SYSTEMS DIAGNOSIS AND REPAIR**	
1	**Battery**	
F-1-1	Inspect, service, and replace battery, battery cables, clamps, and hold-down devices.	Unit 2, Job Sheet 1 & Ass. Sheet 1
F-1-2	Perform battery capacity (load, high-rate discharge) test; determine needed service.	Unit 2, Job Sheet 2
F-1-3	Slow and fast charge conventional/maintenance-free batteries.	Unit 2, Job Sheet 3
2	**Starting System**	
F-2-1	Perform starter current draw test; determine needed repairs.	Unit 2, Job Sheet 4
F-2-2	Perform starter circuit voltage drop tests; determine needed repairs.	Unit 2, Job Sheet 5
F-2-3	Inspect, test, and repair or replace components and wires in the starter control circuit.	Unit 2, Job Sheet 6
B-2-4	Inspect, test, and replace starter relays and solenoids.	Unit 2, Job Sheet 6
3	**Charging System**	
F-3-1	Diagnose charging system problems that cause an undercharge, overcharge, or a no-charge condition.	Unit 2, Ass. Sheet 3
F-3-2	Inspect, adjust, and replace alternator drive belts, pulleys, and fans.	Unit 2, Job Sheet 7
F-3-3	Inspect and repair or replace charging circuit connectors and wires.	Unit 2, Job Sheet 8

(See the next page for NATEF tasks included in *Engine Performance Specialist*.)

NATEF TASKS* found in *Engine Performance Specialist*

	NATEF TASK from the Engine Performance Section: Fuel and Exhaust System Diagnosis and Repair	
14	Perform fuel injector tests (resistance, spray pattern, and pressure drop).	Unit 9, Job Sheet 10
15	Clean fuel injection system on vehicle.	Unit 9, Job Sheet 11
19	Remove and replace fuel tank.	Unit 8, Job Sheet 4
20	Remove and replace fuel gauge sending unit.	Unit 8, Job Sheet 4
24	Test oxygen (O_2) sensor.	Unit 8, Job Sheet 6
25	Remove and replace/reinstall oxygen (O_2).	Unit 8, Job Sheet 7

*National Automotive Technicians Education Foundation, Inc.

SUGGESTED VIDEOS

NOTICE: None of the videos reviewed below show equity relating to race or gender. We cannot recommend them to you in this respect. However, if you choose to use any of these videos, we urge you to discuss the issue of racial and gender equity in the field of automotive technology and use the occasion to encourage all of you students in their career goals.

The following videos are available from ASA Commercial Corporation, P.O Box 1047, Bedford, TX, 76095-1047. 800-272-7467.

- *Computer Command Control(CCC).* Producer: GM Expertec. Two-program series provides a basic understanding of the background and operation of GM's computer command control systems. Also includes a discussion of the federal and state legislation that led to using catalytic converter and computers. Program one concentrates on inputs to the ECM and discusses sensors, switches and signals. Program two identifies the ECM outputs, including the carburetor mixture control solenoid and air injector reactor (AIR) management systems. VHS, 2 tapes, 75 min. total, includes handbook.

- *Engine Noise Diagnosis.* Producer: Ford Parts and Service Division. Describes inner-engine component operation and explains proper and improper performance that creates engine noise. VHS, 34 min.

- *Non-EEC Related Driveability Diagnosis.* Producer: Ford Parts and Service Division. Provides instructional material to diagnose non-EEC related concerns. VHS or Umatic, 45 min., with student text.

- *NVH Vehicle Diagnosis.* Producer: Ford Parts and Service Division. Defines noise, vibration and harshness concerns. Provides diagnostic theory and repair procedures in a step-by-step format. VHS, 26 min.

- *Servicing Computer Command Control.* Two tape program builds on the information presented in the Product Seminar Series, computer command control. Presents driveability problems associated with Quadrajet and Dualjet carburetors. The overhaul of closed-loop Quadrajet and Dualjet is shown, including adjustment procedures. VHS, 90 min.

- *Vehicle Emission Controls.* Producer: Ford Parts and Service Division. Describes how systems function and includes an introduction to emission controls, engine factors affecting combustion, and crankcase evaporative emission controls. VHS, 29 min.

The following videos are available from Bergwall Productions, Inc., 540 Baltimore Pike, Chadds Ford, PA, 19317. 800-645-3565.

- *The Alternator Explained.* Titles include: *Basic Parts and Principles; Charging Problems; Electrical and Mechanical Problems; Overhauling - Assembly; Overhauling - Disassembly and Testing.* Gives an in-depth explanation of how a Delcotron alternator works including overhauling and assembly. VHS, 5 tapes, 12-17 min. each.

- *The Automotive Computer: The Computer in Action.* Explains how the computer actually processes input; shows ROM - PROM - RAM memories, and examines specific computer adjustments on a running automobile; and presents an easy to understand diagnostic approach to computerized automobiles. VHS, 13 min.

- *The Automotive Computer: Explaining the Black Box.* Describes the evolution that led to the introduction of on-board computers, explains the role of the computer in modern automobiles, and introduces sensors - actuators as part of the computer system. VHS, 15 min.

- *The Automotive Computer: Input - Sensors.* Reviews basic electrical principles, describes analog - digital signals, explains how sensors work - 5 volt reference source, and provides a detailed look at sensors including the MAF and the O_2. VHS, 16 min.

- *The Automotive Computer: Output - Actuators.* Explains how actuators convert computer commands into engine control, shows basic operation of solenoids, and describes the use of relays in executing computer commands. VHS, 14 min.

- *The Automotive Cooling System: Basic Parts and Operations* (Part 1); *Basic Parts and Operations* (Part 2); *Problems — Additives and Moving Parts; Problems — Coolant and Air Blockage; Problems — Exhaust Leaks and Unusual Conditions; Problems — External and Internal Leaks.* Explains the basic parts, operations, and troubleshooting of the automotive cooling system. 6 VHS tapes, 10-13 min. each.

- *Automotive Engine Overhaul: Basic Principles and Troubleshooting.* Featuring the GM Oldsmobile DOHC Quad 4 Engine. Introduces the double overhead cam (DOHC) engine. Explains troubleshooting an engine before removal. Details compression testing procedures. Shows how to evaluate spark plugs and exhaust for signs of engine trouble. VHS.

- *Automotive Microprocessors Explained. Auto Body Control Operations; Engine Control Operations; Problems — Causes and Corrections; What They Are and What They Do.* Provides a working knowledge of how the microprocessor is used in automobiles and shows how to repair common microprocessor malfunctions. 4 VHS tapes, 14-17 min. each.

- *Automotive Pollution Control: Basic Causes and Effects.* VHS, 15 min.

- *Automotive Pollution Control: Control Systems and Service.* VHS, 19 min.

- *Automotive Pollution Control: Crankcase Ventilating Systems.* VHS, 13 min.

- *Automotive Pollution Control: Exhaust System.* VHS, 13 min.

- *Automotive Pollution Control: Fuel and Exhaust Gas Recirculation Systems.* VHS, 18 min.

- *Automotive Starting Systems; Component Service and Repair.* Presents procedures for hands-on analysis of the cranking motor. Explains procedures involved in the common bench test. Introduces growler tests. Details removal of the cranking motor from a GM truck. VHS, 12 min.

- *Automotive Starting Systems; How Electric Motors Work.* Describes the role of starting systems. Presents a brief history of the cranking. Explains flux-line interaction of a conductor - permanent magnetic fields. Shows how magnetic push is used to create rotary motion in the armature. VHS, 13 min.

- *Automotive Starting Systems; Inside the Cranking Motor.* Expands electric motor descriptions to a specific design - operation of a cranking motor. Details the location - function of field coils - commutator - brushes. Shows the differences between series - shunt motors. VHS, 12 min.

- *Automotive Starting Systems; Starting the Car.* Describes how components work together to crank the engine. Presents the over-running clutch. Demonstrates how the system engages pinion - ring gear. Introduces the role of the Neutral Safety switch. Explains mechanical advantage. VHS, 11 min.

- *Automotive Starting Systems; System Testing.* Explains the headlight method of system analysis. Describes the diagnosis of various solenoid problems. Introduces the voltage drop test. Demonstrates the use of the carbon load tester to perform load test. VHS, 14 min.

- *Basic Automotive Jobs Explained: Using Reference Material and Starter Replacement; Performing Road Service, Tie Rod End and Idler Arm Replacement; Performing Underhood Services and Muffler Replacement; Changing Engine Oil, Automatic Transmission Fluid, Valve Cover Gasket, and Thermostat Replacement, Alternator, Battery, Shocks and Spark Plug Replacement.* Examines the jobs available in the automotive industry and shows your students how to investigate where employment is available. VHS, 5 tapes each 13-17 min., singles or set available.

- *Carburetion, Ignition, and Cooling,* from *The Internal Combustion Engine* series. Introduces the internal combustion engine and explains how to solve and treat common problems. Other videos in the series: *Basic Parts and Operation, Lubrication and Valve Operation, Valve Problems-Causes and Corrections,* and *How To Do a Valve Job.* 8:44 min. slides-on-video cassette.

- *Carburetion - Related Problems*, from the *Drivability Troubleshooting Hesitation Problems* series. Explains what to look for during a visual inspection of the accelerator pump circuit, choke operation, choke pull off, main metering circuit-idle circuit, demonstrates performance evaluation. Other videos in the series are: *Ignition-Related Problems* and *Fuel-Injection-Related Problems*. Video.

- *The Charging System Explained*. Titles include: *Advanced Alternator Principles; Alternator Construction; Alternator Operating Principles; Alternator Regulators: Vibrating Type; Basic Principles of Operation; Electronic Regulators; Generator - Regulator Operation*. Explains the principles of operation for the charging system. VHS, 7 tapes, 11-18 min. each.

- *Charging Systems Explained: The Alternator*. Describes the increased demand for electrical energy in modern automobiles. Shows how rotating mechanical energy is converted to electrical energy. Introduces rotor - stator - diode assembly - rectifier bridge. Describes the rotor as an electromagnet. Details similarities and differences between Wye-wound and Delta-wound stators. VHS.

- *Charging Systems Explained: The Battery*. Explains the role of the charging system. Details the components of the system. Introduces secondary wet cell battery. Identifies the chemical reaction that creates potential difference. Highlights plate - separators - straps. Describes charging as the reversal of chemical reaction. VHS.

- *Charging Systems Explained: Flux Line Interaction*. Demonstrates rotor rotation - resulting creation of one alternating current cycle. Details flux line interaction between rotor - stator. Shows production of three-phase alternating current. Describes how a rectifier bridge functions - converts alternating current to direct current. VHS.

- *Charging Systems Explained: Troubleshooting*. Describes undercharge - overcharge as most common charging system problems. Shows how to troubleshoot the General Motors CS-144 alternator. Details the analysis of abnormal charging system operation. Highlights general removal - testing of rotor - stator - rectifier bridge - slip rings - brushes. VHS.

- *Charging Systems Explained: The Voltage Regulator*. Explains why a voltage regulator is needed. Describes a regulator as a voltage sensitive switch. Demonstrates the operation of a Delco Remy SI Regulator. Shows how resistors - zener diode work together to turn the system on and off. VHS.

- *Drivability Troubleshooting; The No Start Condition*. Demonstrates customer service skills. Provides an example of diagnostic interview technique. Details a preservice visual inspection. Explains the evaluation of a cranking test - performance - analysis of compression test. VHS.

- *Drivability Troubleshooting; No Start/No Fuel*. Provides a visual inspection of throttle body fuel flow. Shows how to distinguish a fuel flow problem from an electrical problem. Demonstrates a resistance check at injector terminal leads. Details performance - evaluation of fuel pressure test. VHS.

- *Drivability Troubleshooting; No Start/No Spark.* Describes the use of a spark tester to verify voltage through arcing. Demonstrates ignition circuit analysis. Details the disassembly - inspection of distributor. Shows how to use test light to evaluate ignition system triggering pulses. Examines various types of ignition coils. VHS.

- *Electronic Fuel Injection: GM Throttle Body Type.* Examines the GM throttle body type electronic fuel injection parts and troubleshooting common problems. Part 1: *Operation of Basic Parts.* 1 cassette, 17:46 min.; Part 2: *Basic Troubleshooting and Repair.* 1 VHS cassette, 16:16 min.

- *Fuel Injection - Related Problems* from the *Drivability Troubleshooting - Hesitation Problems* series. Shows how to perform a fuel pressure test; explains tests of load sensors (MAP-MAF); demonstrates the test of a throttle position sensor, oxygen sensor, and coolant sensor. 1 VHS cassette.

- *Infrared Exhaust Analyzer: Conducting the Emissions Test; Introduction and Calibration; Locating Causes of Excessive Emissions; Specialized Testing with the Analyzer; Troubleshooting with the Analyzer.* Produced in cooperation with Sun Electric Co. Gives a detailed explanation of how the Infrared Exhaust Analyzer is used to conduct an emissions test and determine overall engine performance. 5 VHS tapes.

- *The Internal Combustion Engine: Basic Parts and Operation.* Part of a series that introduces the internal combustion engine and explains how to solve and treat common problems. VHS, 16 min.

- *The Internal Combustion Engine: Carburetion and Cooling.* Part of a series that introduces the internal combustion engine and explains how to solve and treat common problems. VHS, 9 min.

- *No Start/No Fuel* from the *Driveability Troubleshooting* series. Provides visual inspection of throttle body fuel flow, shows how to distinguish fuel flow problem from electrical problem, demonstrates resistance check at injector terminal leads, and details performance-evaluation of a fuel pressure test. 1 VHS cassette.

- *The Operation of the Fuel System.* Provides a comprehensive overview of the operation of an automotive fuel system. Titles included are: *Basic Parts and Operations,* 10:42 min.; *Fuel Lines, Air Cleaner and the Carburetor,* 14:55 min.; *Carburetor Circuits - Part One,* 11:15 min.; Carburetor Circuits - Part Two, 11:17 min.; *Manifolds and Heat Control*, 12:51 min.; *The Origin of Fuel,* 12:33 min. All VHS.

- *Port Fuel Injection.* Part 1: *An Introduction.* Explains the advantages of fuel injection by reviewing combustion, introduces the electronic control module, explains how environmental conditions affect air, and shows feedback loop from sensors to ECM to injector. 1 VHS cassette, 11:23 min. Part 2: *Operation* *of Basic Parts.* Introduces basic components, explains the difference between throttle body and port fuel injection, describes individual sensors and their function, and injector pulse width. 1 VHS cassette, 17:49 min. Part 3: *Basic Troubleshooting.* Details simple repair procedures, explains how to find and understand codes, and describes solutions to common problems. 1 VHS cassette, 16:28 min.

- *Problems of Internal Combustion Engine: Compression Leaks; Excessive Oil Consumption; Oil Pressure Problems; Unusual Engine Problems.* Explains how to diagnose, troubleshoot, and solve problems of the internal combustion engine. 4 VHS tapes, 12-17 min. each.
- *Scanners Explained: Getting Started.* Introduces the scanner, describes basic function-operation. Examines the basic uses of hand-held computerized test equipment. VHS, 18 min.
- *Scanners Explained: Troubleshooting.* Details the procedure for a key-on/ engine-off test. Shows scanner testing sensors including the MAP, coolant, and others. VHS, 14 min.
- *The Starting System Explained.* Titles include: *Field Coils, Armature and Brushes; Starting Motor Service and Repair; Starting System Testing; The Drive Arrangement and Solenoid.* Identifies starting system components and shows how they are tested and serviced. VHS, 4 tapes, 7-18 min. each.
- *The Sun Interrogator Explained.* Titles include: Basic Operations; Testing Techniques; Test Link. Explains the basic operations and testing techniques of the Sun Interrogator. VHS, 4 tapes, 7-18 min. each.
- *Troubleshooting the Electrical System: The Digital Ohmeter/Voltmeter.* Shows how all important measurements can be conducted with a simple hand-held meter. Explains scales of measurement. Uses real tests to demonstrate voltage - current - resistance measurements. Demonstrates the uses and limitations of a test light. VHS.
- *Troubleshooting Port Fuel Injection.* Part 1: *System Maintenance.* Introduces the proper procedure for maintaining a port fuel injection system, covers the replacement of fuel-air filters, details steps for basic oxygen sensor maintenance. 1 VHS cassette, 16:27 min. Part 2: *Injector Service.* Describes all cleaning procedures for the injectors, explains how to properly-safely check fuel flow in fuel rails-fuel injectors. 1 VHS cassette, 12:11 min. Part 3: *Injector Replacement.* All the steps for properly and safely removing-replacing injectors are described, emphasizes care in disassembly-inspection. 1 VHS cassette, 16:23 min. Part 4: *Throttle Body Service.* Details regular maintenance including idle air control replacement, explains throttle body carbon build-up, and describes throttle body disassembly-cleaning procedures. 1 VHS cassette, 13:01 min. Part 5: *Flow Charts.* Details the importance of determining what is wrong, shows a diagnostic interview with a car owner, and explains how to

follow a flowchart. 1 VHS cassette, 11:08 min. Part 6: *Trouble Codes*. Details the flowchart method of troubleshooting, examines GM trouble codes 21-23-33, and details the use of hand-held scanners for accessing codes-determining problems. 1 VHS, 12:15 min.

- *Troubleshooting with the VAT-40*. Titles include: *Introduction and Meter Reading; Performing System Tests; Testing Battery Performance; Troubleshooting the Charging System; Troubleshooting the Starting System*. Produced in cooperation with Sun Electric Co. Teaches your students how to perform troubleshooting operations on an automotive electrical system with the VAT-40. VHS, 5 tapes, 15-19 min. each.

- *The Turbocharger Explained*. Provides a working knowledge of the turbocharger and shows how to repair common turbocharger malfunctions. Includes *Operating Principles*, 17:40 min; *Basic Parts I*, 15:47 min., *Basic Parts II*, 15:09 min., *Problem Diagnosis/Service Procedures-Part I*, 16:14 min., *Problem Diagnosis/Service Procedures-Part II*, 17:03 min. 5 slides-on-video cassettes.

The following videos are available from the Chrysler Corporation, CIMS 423-10-14, P.O. Box 1718, Detroit, MI, 48288-1718. 800-626-1523.

- *Battery Service*. VHS or BETA.

- *Noise Diagnosis - Engine Belts*. VHS.

The following videos are available from the Dana Corporation, P. O. Box 453, Toledo, Ohio, 43692-0453. 419-535-4300.

- *Engine Diagnosis and The Cooling System*. Discusses the steps in engine diagnosis and common cooling system problems and failures. VHS, 11 min.

- *Engines of the 90's*. VHS.

The following videos are available from Ford Service Publications, P.O. Box 07150, Detroit, MI., 48207. 800-782-4356. FAX 313-883-1041.

- *Before Code 11*. Provides instructions for the successful diagnosis of engine related concerns not associated with the EEC/MCU systems. Discusses proper tools and inspection procedures. Includes TSB index of driveability concerns. VHS, 24 min., with student text.

- *Carburetor 1977-1982 Diagnosis, Adjustment and Operation*. Discusses diagnosis, adjustment and operation of the Variable Venturi Carburetor. Provides propane enrichment idle mixture adjustment procedure. Contains modifications from 1977-82 as well as complete carburetor specifications. Color VHS, 25:02 min. Includes Student Text.

- *Cylinder Head Service.* Provides information required to understand and service the four-stroke gasoline engine cylinder head, valve train, and other related components. Includes a glossary of cylinder head service tools and terminology. VHS, 47 min., includes student text.

- *Distributorless Ignition.* Describes the functions and operations of the distributorless ignition system and its components; compares DIS to previous ignition systems and provides a review of the fundamentals; includes diagnosis, testing, and service procedures. Utilizes Real System Trainer. VHS, 47 min., student text .

- *EEC-Related Driveability Diagnosis.* Provides instructional material necessary to identify and diagnose electronic engine control (EEC) related driveability concerns utilizing the car/truck engine emission diagnosis (Volume H) shop manual. VHS or UMC, 39 min.

- *EEC System Operation.* Describes the Ford Electronic Engine Control System, identifies engine systems and operations controlled by the EEC System. Describes operation of electronic control assembly (ECA). Illustrates the function and operation of all EEC input and output components. VHS or UMC, 46 min.

- *Electronic Distributorless Ignition Systems.* This introduction to EDIS covers component description, identification, operation and function. It also discusses the differences and advantages of EDIS and DIS, as well as diagnostic equipment and procedures. Utilizes Real System Trainer. VHS, 47 min., student text.

- *Electronic Fuel Injection.* Provides an understanding of the principles and components of electronic fuel injection systems. Details diagnosis, adjustments, and special tools and test equipment required. Color video, 27:00 min. Includes student text.

- *Electronic Fuel Injection: Operation and Diagnosis.* Provides an understanding of the principles and components of electronic fuel injection systems. Details diagnosis, adjustments and special tools and test equipment required. Color video, 33:53 min. Includes student text.

- *Engine, Fuel, and Emission Systems.* Describes carburetion, fuel injection, and emission systems. VHS, 1 hr. 55 min.

- *Engine Performance Intermittent Diagnosis.* Demonstrates procedures for the correct diagnosis of intermittent faults. Covers the preliminary steps for engine performance diagnosis, equipment and adapters required to diagnosis of Electronic Engine Control systems, and actual case studies. VHS, 22 min.

- *Engine Systems.* VHS, 22 min, self-study booklet.

- *Fuel Delivery* section from *Engine Systems.* Vital information about the engine, fuel delivery, cooling, lubrication, exhaust, and emission control systems. Clear graphics and explanations that are easy to understand. Self-study booklet and VHS video tape.

- *1983-1984 Electronic Engine Control (EEC-IV) Self Test Procedures.* The EEC IV system is designed and built to identify problems within itself. This videotape indicates when to look for a problem, how to probe the system for problem identification, and problem resolution. Includes self-test procedures for all EEC-IV systems and repair guidelines that apply. *Part One* covers preliminary checks, recommended test equipment, and how to perform a self test. *Part Two* covers pinpoint testing, verifying repair, component function, and service code interpretation. VHS, 54 min.

- *Vehicle Emission Controls.* Describes how systems function and include an introduction to emission controls, engine factors affecting combustion and crankcase evaporative emission controls. VHS, 29 min.

The following video is available from Guidance Associates, P.O. Box 1000 Mount Kisco, NY 10549-9989, (800) 431-1241.

- *Electronic Fuel Injection: Basic Systems and Troubleshooting.* Explains the function and operation of fuel injector systems by illustrating the components. Describes how to disassemble and reassemble the throttle body and how the multiport injection system works. Demonstrates troubleshooting procedures. 60 min. Video.

The following video is available from HOBAR Publications, 1234 Tiller Lane, St. Paul, MN, 55112. 612-633-3170.

- *Engine Performance and Tune-Up.* This video tape covers basic ignition theory, service procedures, and troubleshooting techniques in a variety of automobiles. Covered are the replacement of component parts, diagnosis and solving problems, and troubleshooting computer controls as well as other electronics. VHS, 73 min.

The following videos are available from Kent-Moore Tool & Equipment Division, SPX Corporation, 28635 Mound Road, Warren, MI 48092-3499. 800-345-2233.

- *Advanced Engine Performance.* Provides advanced service information and diagnosis guidelines for the EEC-IV system; includes strategies for optimum engine performance; explains the relationship between the EEC-IV system and its subsystems. Utilizes Real System Trainer. 247 pg. instructor's guide, 37 color slides, reference book, VHS tape, 32 min.

- *C3 Carburetor Overhaul.* Includes *Complete Carburetor Overhaul, System Performance Check, Mixture Control Solenoid Adjustment, Vacuum Break Adjustment, Idle Mixture Adjustment,* and *Float Level Adjustment.* 2 cassettes, 1 hour.

- *Canister/EGR.* GM Expertec. Two-program series focuses on the vapor canister and EGR valves. *Program One* primarily discusses how each component works and what malfunctions may result in driveability problems. *Program Two* covers the EGR valve and provides a review of the port valve, as well as both the positive and negative backpressure valves. Includes identification, recognition of malfunction symptoms and testing, both on and off the engine. VHS, 2 tapes, 1 hour total.

- *Canister and EGR.* This two videotape program focuses on the vapor canister and EGR valves as well as the newer, integrated electronic EGR valve. Besides a review of how each component works, this program identifies potential malfunctions, including those that may lead to driveability problems. Step-by-step diagnostic procedures are also detailed in this program. VHS, 1 hr., English or Spanish.

- *Computer Command Control.* This two videotape program provides a basic understanding of GM's Computer Command Control (CCC) system's operation. It also discusses sensors, switches and signals and identifies the many ECM outputs, including the Carburetor Mixture Control Solenoid and air injector reactor (AIR) systems. A support handbook is included in this tape series. VHS, 90 min.

- *Dual Jet/Quadrajet Carburetors.* Includes *Diagnosis and Repair, Identifying, 2,3, and 4 Point Carburetors, Bench disassembly, Component Inspecting, and Reassembly,* and *On-Car Adjustment of TPS and MC Solenoid.* 1 cassette, 42 min.

- *Engine Series.* Each GM Expertec engine series consists of four video programs and a support handbook. The first program, the overview, explores unique engine features. Program two provides a thorough explanation of the fuel control system. Program three details the ignition system and program four, diagnostics, shows you how to maintain all of these systems. *Overview*: identifies both standard and special engine features. It also discusses which input and output devices are found on the engine and illustrates how the ECM controls overall engine operation based on its programming and vehicle calibration. *Fuel System*: describes in detail how fuel systems in each engine work. Shows how fuel control is accomplished in TBI and PFI systems, depending on the engine series selected. *Ignition System*: describes specific engine information an how both conventional and more recent distributorless systems work. Factors that affect ECM control of spark advance are also described. *Diagnostics*: presents a logical, systematic way to solve driveability problems and describes the "service engine soon" light and its proper interpretation. Also describes the use of hand-held diagnostic tools. Series titles are: 2.3 Liter Quad 4, 5.0/5.7 Liter TBI 220 (Truck), 3.0/3.8 Liter PFI, 2.8 Liter (Generation II) PFI, 2.8 Liter (Generation I) PFI, 2.5 Liter TBI. VHS, five 2 hr. tapes, one 3 hr. tape.

- *Fuel System* from General Motors' *Engine Series.* Describes in detail how fuel systems in each engine work. Shows how fuel control is accomplished in TBI and PFI systems depending on the engine series selected. *2.3 Liter Quad 4*, 2 hours; *5.0/5.7 Liter TBI 220 (Truck)*, 2 hours; *2.8 Liter (Generation II) PFI*, 3 hours; *2.8 Liter (Generation I) PFI* , 2 hours; 2.5 Liter TBI, 2 hours.

- *Servicing Computer Command Control.* This two videotape program builds on the information presented in the Product Seminar Series, Computer Command Control. Diagnosing driveability problems associated with Quadrajet and Dualjet Carburetors are present. The process shown enables the technician to systematically eliminate other possible causes of driveability complaints before servicing the carburetor. The complete overhaul of closed loop Quadrajet and Dualjet is shown, including adjustment procedures. VHS, 2 tapes, 1.5 hours.

The following videos are available from The Media Center, State Fair Community College, 3201 West 16th Street, Sedalia, MO, 65301. 800-875-8615. FAX 816-530-5820.

- *Computerized System Controls.* The basic components of a computerized engine system are identified and described, including the ECM/PCM, individual sensors and controllers, and open loop/closed loop operations. VHS, 8 min.

- *Computer System Sensor Testing.* This program identifies the equipment required for sensor testing and describes the procedure for testing an oxygen sensor, a manifold absolute pressure (MAP) sensor, and a throttle position sensor (TPS). VHS, 6 min.

- *Turbocharger Servicing and Diagnostic Procedures.* Service procedures for a turbocharged engine are described, including oil change, inlet-air service inspection, exhaust side inspection, and diagnostic procedures for turbocharger malfunctions. 6:38 min. video.

- *Turbocharger Theory and Operation.* This video provides instruction in the components of a turbocharger, the advantages and disadvantages of turbocharging, the intercooling process of boosted air, volumetric efficiency, and the wastegate system for boost control. 8:20 min. video.

The following videos are available from Meredian Education Corporation, Dept. VC92, 236 E. Front St., Bloomington, IL, 61701. 800-727-5507.

- *Automotive Computer Self-Diagnosis.* Summarizes how to read computer trouble codes, Ford, General Motors, Chrysler and other makes are discussed so the student knows how to trigger self-diagnosis without using a scan tool. This information applies to almost any make or model of car. VHS, 25 min.

- *Automotive Computer System Operation.* Makes a complex computer system seem simple with easy to understand language and computer generated artwork. How a computer system uses information from sensors to control the operation of other devices and systems. Sensors and actuators are divided into basic categories. VHS, 25 min.

- *Automotive Computer System Service.* Shows how to do basic tests and repair procedures on a computer system: the problem sources, symptoms, tests, and repairs need to fix common malfunctions. VHS, 25 min.

- *Charging System Construction and Operation.* The operation of the alternator, voltage regulator, and wiring diagrams are all presented to prepare students to be more adept at diagnosing and repairing charging systems. High voltage systems are also introduced. VHS.

- *Charging System Service.* This video uses down-to-earth, simple methods for troubleshooting and repairing most charging system failures. It shows how to use a load tester and a hand-held multimeter to check system operation before explaining how to replace and service components. Alternator rebuilding is summarized. VHS.

- *Cooling System Service.* The video shows the proper way to service a car's cooling system. It demonstrates when and how to replace the belts, hoses and thermostat, along with procedures for draining, flushing, and replenishing the radiator. VHS.

- *Engine Fundamentals.* This entertaining video uses 3D modeled animation and live action video to explain the basic operating principles of a 4-stroke cycle piston engine. You will watch as a simple engine is built from the block up to produce an animated running one-cylinder engine. An excellent training tape for courses in automechanics, general technology, small gas engines, farm mechanics, science, drivers education, industrial arts, etc. VHS, 25 min.

- *Gasoline Injection System Operation.* This live action animated video explains the operation of an electronic fuel injection system. Computer generated animation and actual components are used to show how a modern fuel injection system functions. The information in this video is generic and applies to all makes and models of cars using electronic fuel injection. 25 min., video.

- *Gasoline Injection System Service.* This video uses 3-D computer animation and live action footage to show how to do basic tests and repairs on an electronic fuel injection system. It discusses the problem, systems, tests, and repairs needed to fix typical injection system malfunctions. 25 min., video.

- *Scanning Automotive Computer Problems.* A follow-up to *Computer Self Diagnosis*: how to use several types of scanning tools, to analyze difficult to locate computer system problems. General scanner use, computer electrical values, and modem type analysis systems are shown. VHS, 25 min.

- *Starting System Operation.* Explains the theoretical elements that will be useful to a mechanic before studying how to repair a starting system. The starting motor, solenoid, ignition switch, cables, current draw levels, and other beneficial information is presented. VHS.

- *Starting System Service.* This program starts with troubleshooting, then goes into specific tests for verifying your conclusions. Methods for replacing and servicing components are detailed. Starting motor rebuilding is summarized. VHS.

- *Using a Load Tester.* This video uses 3D animation and live-action to show how to use typical load testers. Battery, alternator, starter, and other tests are demonstrated on both analog and digital load testers. The animation shows what is happening inside the tester and circuit during each test. VHS, 25 min.

The following video is available from the National AudioVisual Center, Customer Services Section, 8700 Edgeworth Drive, Capitol Heights, MD 20743-3701, (301) 763-1896.

- *Carburetor, Principles of Operation.* Explains the major components of a carburetor-bore, bowl and air throttle. Tells how air pressure differential is utilized. Shows application of the venturi principle, metering, atomization, vaporization, and the operation of carburetor circuits-floats, low speed, high speed, accelerator pump, and choke. 25 min. b&w. VHS video.

The following videos area available from NIMCO, Route 2, Box 301B, Calhoun, Kentucky, 42327. 800-962-6662.

- *Air and Vapor Pollution Controls.* Air Injection System describes preliminary inspection of both air pump injection systems and pulse-air injection systems, demonstrates check valve test, diverter valve test, and coolant-controlled engine vacuum switch test. Air Temperature Control Systems demonstrates how to inspect, test and repair components of thermostatically controlled air cleaners, shows preliminary inspection, testing of vacuum motors, sensors or thermostatic bulbs. Fuel Vapor Control Systems shows how to inspect the carbon element, purge valve and overfill-limiter valve, gives procedures for replacing components. Intake Manifold Heat Control shows servicing procedures for thermostatic, vacuum-operated and hot coolant mixture preheating systems, illustrates thermostatic testing. VHS, program guide.

- *The Allen Smart Scope Explained.* Basic Parts identifies basic parts, demonstrates operation of light pen, describes instruments used on Smart Scope, calibration of instruments. Testing and Maintenance details connection of Smart Scope to vehicle components for system checking, provides sample reference screens, covers maintenance demonstrations including basic cleaning, filter changing. 2 VHS tapes, 15-16 min. each, study guide.

- *Alternator Explained.* Includes: *Basic Parts and Principles, Charging Problems, Electrical and Mechanical Problems, Overhauling—Disassembly and Testing*, and *Overhauling — Assembly*. VHS, 5 tapes, 12-15 min. each.

- *The Automotive Cooling System: Basic Parts and Operations (Part 1); Basic Parts and Operations (Part 2); Problems — Additives and Moving Parts; Problems — Coolant and Air Blockage; Problems — Exhaust Leaks and Unusual Conditions;*

Problems — External and Internal Leaks. 6 VHS tapes, 10-13. min each and study guide.

- *Automotive Microprocessors Explained. Auto Body Control Operations; Engine Control Operations; Problems — Causes and Corrections; What They Are and What They Do;* shows engine and body functions controlled by a microprocessor, demonstrates how each function operates. 4 VHS tapes, 17-20 min. each, and study guide.

- *Automotive Pollution Control: Basic Causes and Effects; Control Systems and Service; Crankcase Ventilating Systems; Exhaust System; Fuel and Exhaust Gas Recirculation Systems.* 5 VHS tapes, 12-14 min. each, study guide.

- *The Basics of Automobile Computer Control Sensors. How the Coolant Temperature Sensor Works* identifies the location of the coolant temperature sensor, defines the role of the sensor in controlling fuel delivery, ignition timing, idle speed and exhaust gas recirculation, and illustrates in detail how the sensor works. *How the Knock Sensor Works* explains what the knock sensor does, examines how the computer uses the signal from the sensor in dealing with ignition timing control, and shows how a basic diagnostic test is made. *How the MAP and BARO Sensors Work* defines MAP and BARO sensors, explains the job of MAP and BARO sensors in maintaining good engine performance, and illustrates how sensors signal the computer. *How the Oxygen Sensor Works* defines job of the oxygen sensor in exhaust emission control, discusses how the air-fuel mixture affects the sensor, and explains the way in which the sensor signals the computer. *How the Throttle Position Sensor Works* describes what this sensor does, explains how the computer reacts to the information, and illustrates how the fuel supplied to the engine's intake is affected. 5 VHS tapes and program guide.

- *The Battery and Its Electrical System.* Help your students learn how to install a battery and service an electrical system in this colorful live-action video. The program demonstrates battery activation and installation and shows how to test the starter, voltage regulator and alternator. It also explains how and why there are differences in battery quality. VHS.

- *Carburetion, Ignition, and Cooling,* from *The Internal Combustion Engine* series. Introduces the internal combustion engine and explains how to solve and treat common problems. Other videos in the series: *Basic Parts and Operation, Lubrication and Valve Operation, Valve Problems-Causes and Corrections,* and *How To Do a Valve Job.* 5 VHS slides-on-video cassettes, 8-16 min. each, study guide.

- *Carburetor Service.* Four-part series: *Carburetor Float and Accelerator Pump Adjustment.* Describes adjustments to the carburetor float, including float level, float alignment, float drop and float toe. Demonstrates fast accelerator pump and idle adjustment in detail. *Carburetor Removal and Overhaul.* Demonstrates carburetor removal, overhaul, disassembly, cleaning, assembly, adjustment, and reinstallation. *Idle Speed and Carburetor Mixture Adjustment.* Explains lean-drop method, lean-best-idle method, one-quarter-turn-rich method, and infrared analyzer method. *Idle Speed Controls.* Shows testing, and adjustment of the throttle stop solenoid, throttle positioner and deceleration control system. Live-action video, 4 parts, 60 min.

- *Charging System Explained.* Includes: Basic Principles of Operation; Generator—Regulator Operation; Alternator Construction; Alternator Operating Principles; Advanced Alternator Principles; Alternator Regulators: Vibrating Type; Electronic Regulators. VHS, 7 tapes, 12-16 min. each.

- *Computer Command Control.* Actual diagnosis and repair, not just theory. *Theory of Operation, System Performance Check, Carburetor Dwell, Sensor Diagnosis, Parameters for Each Sensor, Trouble Code Identification, Most Common Faults with Each Code, Tools Used to Diagnose System.* 4 VHS tapes, 2.5 hours, 4 tests.

- *Computer Command Control - Carburetor Overhaul Procedures.* Actual Diagnosis and Repair, not just theory. *System Performance Check; Removal of Idle Mixture Tamper Resistant Plug, Idle Air Bleed Plug, and Throttle Position Sensor Plug; Complete Carburetor Overhaul; All Internal and External Adjustments*; also includes *Mixture Control Solenoid Adjustment; Proper Vacuum Brake Adjustment; Idle Mixture Adjustment*; and *Tools Needed to Overhaul Carburetor.* 2 VHS videos, 1 hour.

- *Computer Control: Ford and GM.* Here's an opportunity to find out the fundamental concepts and the hands-on information for today's computerized engines. *Basic Diagnostic Testing (Ford)* introduces Ford's service manual, describes how to inspect the car, and shows how to get basic diagnostic information from the car's computer. *Basic Diagnostic Testing (GM)* describes the advantage of the self-diagnostic capability of the CCC system, explains the role of the ECM, shows how to activate the system, illustrates how service code is displayed, shows how to use the service code, and emphasizes the importance of manufacturer's manuals in the repair process. *GM Computer Command Control System (CCC)* provides an overview of CCC, explains how the driver is warned of engine failure, describes the ECM and its components, details where sensors and controls are located. *Ford Engine Electronic Control System (EEC)* defines the EEC system, describes the sensors, switches and actuators, compares the Ford EEC to other systems, and shows how to troubleshoot sensors and controls. 4 VHS tapes, program guide.

- *The Computer in the Automobile: Systems and Components.* Evolution and Applications; Integrated Circuits: the Computer's Brain; On-Board Computer Vocabulary; Test Equipment; The System and Its Components. The advent of computer-control systems in automobiles has changed the way engine malfunctions are analyzed and has presented new challenges for the auto technician. 5 VHS tapes, program guide.

- *Digital and Analog Meters.* Fundamentals, electrical units of measurement, meter used in diagnosis computer cars, troubleshooting practices, test light/volt meter, self-powered test light/ohmmeter, ammeter. VHS, 1 hr., 2 tapes, 2 tests.

- *EEC IV Diagnosis (with Monitor 2000).* Computed timing check, output state check and wiggle test, diagnosis of problem vehicles using Monitor 2000, and using Monitor 2000 mode "8". Ford products. VHS, 19 min.

- *EEC IV Diagnosis (with Voltmeter).* Description of "Quick Test" and essential tool requirements, preliminary tests prior to performing Quick Test, fast codes, on-demand codes, separator codes and continuous memory codes. Ford products. VHS, 24 min.

- *EEC IV/EFI Diagnosis and Service.* Diagnosing individual components in the EFI system, cruise control diagnosis using the Monitor 2000, thick film ignition diagnosis. Ford products. VHS, 25 min.

- *EFI On-Board Diagnosis.* Description operation of system components, system interrogation using Monitor 2000, system switch tests, ATM tests, data line tests. Chrysler products. VHS, 33 min.

- *Electronic Fuel Injection:* (1) *Operation of Basic Parts* and (2) *Basic Troubleshooting and Repair.* Video transfer. 2 VHS cassettes (16-18 min. each), study guide.

- *Emission Controls*. Includes: *Fuel Management; Air Management; Ignition Spark Management Systems; Choke System; Early Fuel Evaporation (EFE); Exhaust Gas Recirculation (EGR); Air Injection Reactor (AIR); Thermal Air Cleaner.* General Motors. 2 VHS tapes, 1 hour.

- *Engine Computer Testing Procedures. Self-Testing* illustrates safety precautions, describes use of trouble codes as a diagnostic tool, and demonstrates a self-test. *Pinpoint Testing* defines trouble codes, outlines preliminary procedures for pinpoint testing, and discusses diagnostic charts. *Sensor Testing and Service* includes testing and service of EGO sensor, mixture control or MC solenoid, and throttle position solenoid, and defines actuator resistance and programmable read-only memory. VHS, 3 parts, program guide.

- *Engine Diagnostic Procedures.* Includes: preliminary diagnostic inspection, vacuum and power balance testing, cylinder compression and cylinder leakage testing, and engine and exhaust gas analyzers. VHS, 1 hour.

- *Engine Diagnostic Procedures. Preliminary Diagnostic Inspection* demonstrates typical inspection procedure, shows how to conduct comprehensive visual inspection and sound, smoke-color and odor analysis. *Vacuum and Power Balance Testing* demonstrate cranking vacuum and speed testing, PCV quick testing, manifold vacuum testing and power balance testing. *Cylinder Compression and Cylinder Leakage Testing* demonstrates basic compression test, wet compression test, cylinder leakage test, and compares test results with a power balance test. *Engine and Exhaust Gas Analyzers* introduces a typical engine analyzer, outlines four main sections: oscilloscope, CRT-diagnostic computer, pneumatic section, and infrared exhaust gas analyzer. 4 part VHS, program guide.

- *Engine Troubleshooting: Testing and Procedures.* Series. 2 VHS tapes.

- *Exhaust and Crankcase Pollution Controls. Positive Crankcase Ventilation* illustrates PCV vacuum tests using both a tester and an index card, shows PCV vacuum and speed drop tests, cranking vacuum test, and filter cleaning and PCV valve replacement. *Exhaust Gas Recirculation* illustrates preliminary testing procedures, shows procedures for general system testing and detailed system vacuum testing, and demonstrates removing, cleaning and replacing of EGR valve. VHS, program guide.

- *Exhaust System Testing and Service. Exhaust System Service* demonstrates how to remove and replace the exhaust manifold and shows how to assemble and disassemble the exhaust system, including the catalytic converter. *Catalytic Converter Inspection* discusses safety precautions, shows how to check engine vacuum with a vacuum gauge, how to test exhaust emissions with an infrared analyzer, and demonstrates the replacement of the catalyst in a pellet type converter. 2 parts on VHS, program guide.

- *Ford EEC I, II, III & IV 1978-87.* Electronic engine controls, troubleshooting, feedback carburetor/electronic fuel injection, service code sequence, procedure for extracting codes from EEC, explanation of service codes-what they are and what they mean. VHS, 2.25 hrs, 3 tapes, 3 tests.

- *Ford EEC-IV.* Electronic engine controls, thick film integration ignition module, sensors and parameters, bench tests, trouble codes and history, fuel/air management, sensors and solenoids. VHS, 3 tapes, 2.25 hrs.

- *Ford EEC I, II, III & IV 1978-87.* Electronic engine controls, troubleshooting, feedback carburetor/electronic fuel injection, service code sequence, procedure for extracting codes from EEC, explanation of service codes-what they are and what they mean. VHS, 2.25 hrs, 3 tapes, 3 tests.

- *Ford EEC-IV.* Electronic engine controls, thick film integration ignition module, sensors and parameters, bench tests, trouble codes and history, fuel/air management, sensors and solenoids. VHS, 3 tapes, 2.25 hrs.

- *4-Gas Emission Tests: Mechanical Condition of Engine; Propane Enrichment Test; Exhaust Gas Analysis; EGR Value Test; Cylinder Power Balance Test; Lean Drop Test.* VHS, 42 min.

- *Fuel Delivery Systems.* Includes sections on *Fuel Storage Inspection* (Outlines safety precautions, demonstrates inspection and testing of fuel lines, mountings and fittings, vacuum lines and valves, and fuel tank system components.) and *Fuel Pump and Filter Inspection* (Gives procedures for performing pressure, capacity, vacuum and electrical tests on electrical pumps, shows how to remove mechanical and electrical pumps, and describes inlet filter service.). 2 videos.

- *Fuel Injection System Service.* Part 1: *Port Fuel Injection Systems.* Illustrates the servicing of gasoline fuel injection systems, gives procedures for sensor testing, fuel pressure relief, pressure testing, injector testing and idle adjustments. Part 2: *Throttle Body Fuel Injection Systems.* Illustrates the servicing of gasoline fuel injection systems, gives procedures for sensor testing, fuel pressure relief, pressure testing, injector testing and idle adjustments. Live action video. 3 parts, 30 min.

- *Fuel Management* from the series, *Emission Controls.* Other titles in the series are: *Air Management; Ignition Spark Management Systems; Choke System; Early Fuel Evaporation EFE; Exhaust Gas Recirculation EGR; Air Injection Reactor AIR; Thermal Air Cleaner.* VHS.

- *Honda PGM-FI Operation and Diagnosis.* Diagnostic procedures and essential tools, fuel metering system function and operation, troubleshooting tips and diagnosis of several common faults. VHS, 37 min.

- *How to do a Major Engine Tune-Up: Final Adjustments and Electronic Testing; Preventative Maintenance Techniques; The Right Approach.* 3 VHS tapes, 13-16 min. each, and study guide.

- *How to Overhaul a Carburetor.* Three-part program demonstrates the disassembly, cleaning, internal adjustments and reassembly of the carburetor. Describes external adjustments that are made while the engine is running. Video transfer: 3 cassettes, 12 min. each.

- *The Internal Combustion Engine: Basic Parts and Operation; Carburetion and Cooling; How to do a Valve Job; Lubrication and Valve Operation; Valve Problems — Causes and Corrections.* 5 VHS tapes, 8-16 min. each, study guide.

- *The Internal Combustion Engine. Basic Parts and Operation. Lubrication and Valve Operation. Carburetion, Ignition and Cooling. Valve Problems - Causes and Corrections. How to do a Valve Job.* 5 VHS tapes, 8-16 min each, study guide .

- *Keep Your Car Cool Care Cooling System Service.* This set teaches you the proper way to service your car's cooling system. It will demonstrate how and when to replace the belts, hoses and thermostat and show you how to drain, flush, and replenish the radiator. VHS.

- *Latest Codes, Components and Diagnosis.* Trouble codes and diagnostic techniques, special test equipment applications, operation and diagnosis of new components. GM products. VHS, 35 min.

- *MCU Diagnosis (with Monitor 2000).* Description and operation of input controlled components, performing functional self-test (KOEO-KOER), performing spark knock functional test. Ford products. VHS, 28 min.

- *Nissan ECCS Diagnosis.* ECCS self diagnosis systems (2 & 5 mode), use of ECU inspection lamps for diagnosis, use of checker box on Mode 5 systems. VHS, 33 min.

- *Port Fuel Injection.* Actual Diagnosis and Repair. not just theory. Part 1: *An Introduction,* Part 2: *Operation of Basic Parts,* Part 3: *Basic Troubleshooting.* 3 live action videos.

- *The Problems of the Fuel System.* Includes 6 programs: *Fuel Tank, Lines and Gauge; Fuel Pump, Filter and Vapor Lock; Carburetor Assembly-Part One; Carburetor Assembly-Part Two; Carburetor Assembly and Air Cleaner; Manifolds and Combustion Problems.* 9-14 min. each, study guide.

- *Problems of Internal Combustion Engine: Compression Leaks; Excessive Oil Consumption; Oil Pressure Problems; Unusual Engine Problems.* 4 VHS tapes, 12-17 min. each, and study guide.

- *Scope Interpretation/Engine Performance Testing.* Scope patterns, cranking test, running test, cylinder power balance test, ignition system testing, charging systems, firing KV. VHS, 2 tapes, 2 tests.

- *Servicing the General Motors Emission Control System.* Help your students master the GM emission-control system with this hands-on treatment of the subject. *The Electronic Control Module (ECM)* discusses how the ECM works, describes the programmable Read Only Memory (PROM), illustrates how to replace the PROM unit, and illustrates how to replace the ECM unit. *Thermostatic Air-Cleaner Operation and Repair* describes how a malfunctioning air cleaner affects exhaust emission, and illustrates removal and replacement of defective units. *Troubleshooting the Coolant Sensor* shows the relationship of a flashing engine check light to a faulty cooling sensor, gives an analysis of potential problems, and describes repair procedures. *Troubleshooting the Diverter Valve* shows how the valve works, explains what happens when it fails, describes testing the valve, and details replacing a defective valve. *Troubleshooting the Exhaust Gas Recirculating Valve (EGR)* explains how the valve works and describes how it can be tested and replaced. *Troubleshooting the Oxygen Sensor* shows the relationship of a flashing engine check light to a faulty oxygen sensor, explains how to test for problems, and illustrates step-by-step stages of repair. 6 VHS and program guide.

- *Single Module Engine Controller System.* Operation and testing of the SMEC system components, pintle type idle speed control, and system interrogation using Monitor 2000. VHS, 34 min.

- *Starting System Explained: Field Coils, Armature and Brushes; The Drive Arrangement and Solenoid; Starting System Testing; Starting Motor Service and Repair.* VHS, 4 tapes, 11-13 min. each with study guide.

- *The Sun Interrogator Explained. Basic Operation* explains the set-up and operation on Interrogator, test link computer system, details the use of the voice prompter, printer, various controls, shows use of cables, leads, probes, and demonstrates the hook-up to an automobile. *Testing Procedure* details the warm-up procedure, calibration, keypad operation, vehicle code, specification, explains high cruise, low cruise, idle testing, and includes step-by-step demonstrations. Test Link. 3 VHS tapes, study guide.

- *TBI Adjustment Procedures.* TPS adjustment, ISC adjustment, proper connecting of digital volt-ohm meter, precautions to protect ECM during adjustments, idle speed adjustments, and correcting possible trouble spots after adjustment. VHS, 2 tapes, 42 min.

- *TBI & PFI Diagnosis (with Monitor 2000).* Description and operation of system components, operation and testing of system inputs components, system interrogation using the Monitor 2000, and special diagnostic state operation. GM products. VHS, 40 min.
- *Throttle Body Adjustment Procedures.* Actual diagnosis and repair, not just theory. Check TPS adjustment to determine if adjustment is necessary; Proper connecting of digital-volt ohm meter; Precautions to protect ECM during adjustment; Proper idle speed adjustments; Correcting possible trouble spots after completed adjustments. 2 VHS videos, 40 min.
- *Throttle Body Injection (TBI) 1980-87.* Actual diagnosis and repair not just theory. Theory of operation; System and component operation of all sensors and solenoids; Covers each code in detail; Trouble code identification; Field service mode; Tools needed to diagnose system: Parameters for each sensor. 4 VHS videos, 2 ¼ hrs.
- *Toyota TCCS Diagnosis.* System description, function and operation, inputs and controlled systems, TCCS diagnosis using voltmeter. VHS, 25 min.
- *Troubleshooting Exhaust and Emission Control Systems.* 3 VHS tapes.
- *Troubleshooting with the VAT-40.* Titles include: *Introduction and Meter Reading,* how to identify starting and charging system problems - connection procedure - explains use of each meter - interpretation of readings; *Performance System Tests*; *Testing Battery Performance*; *Troubleshooting the Charging System,* shows in-car tests of alternator, generator - how to perform regulator bypass tests - how to locate excessive voltage drops in charging circuits - circuit resistance tests; *Troubleshooting the Starting System.* VHS, 5 tapes, 11-14 min. each.
- *The Turbocharger Explained.* Includes *Operating Principles, Basic Parts I, Basic Parts II, Problem Diagnosis/Service Procedures—Part I, Problem Diagnosis /Service Procedures—Part II,* 5 VHS cassettes 15-18 min. each, study guide.
- *Turbocharger Testing and Service. Testing Procedures,* includes removal and bench testing, and shows how bearing axial clearance and radial clearance tests are performed. *Servicing Procedures,* describes procedures for the installation of a turbocharger unit and for bearing lubrication. 2 part video.
- *Understanding the Turbocharger.* This program analyzes the turbocharger from every angle. With colorful photos and detailed narration, it will tell your students all there is to know about this powerful booster. Includes: *Troubleshooting a Turbocharger.* Introduces the unit, illustrates components, shows how to analyze a malfunctioning turbocharger, and includes listening to

engine sounds to examine components. *Disassembling the Unit.* Uses a Garrett turbocharger as a demonstration model, and details the specialized equipment required for procedure for disassembling major subassemblies. *Rebuilding the Center Housing and Rotating Assembly.* Explains the way the center housing and the rotating assembly work, describes why mechanical problems develop in these two components, and demonstrates how to disassemble and reassemble the center housing and rotating assembly, includes inspection. *Final Inspection and Assembly.* Discusses how the center housing and rotating assembly are prepared for re-use, describes in detail the inspection process for each component, and demonstrates the step-by step procedure for reassembling the entire unit. 4 part video, program guide.

- *What Your Car is Trying to Tell You: Basic Maintenance; Recognizing the Problems; Symptoms of the Problems.* 3 VHS tapes, 12-14 min. each, study guide.

The following videos are available from Opportunities for Learning, Inc., Career Aids Division, 941 Hickory Lane, Dept. X V 6 7 8, P.O. Box 8103, Mansfield, OH, 44901-8103. 419-589-1700. 800-243-7116.

- *The Basic Engine Videotapes.* Includes titles: *The Four-Stroke-Cycle Internal Combustion Engine, Engine Components, Valve Mechanisms and the Two-Stoke-Cycle, The Fuel System,* and *The Lubricating and Cooling Systems.* Presents a thorough introduction to the internal combustion engine. 3 VHS tapes.

- *Engine Performance and Tune-Up Video.* As a complete video tune-up manual, this program covers ignition systems, engine servicing, and troubleshooting for 4, 6, and 8 cylinder engines. Diagrams, working models, and cutaways are used for an in-depth exploration of ignition system theory. Logical troubleshooting procedures are used to solve common engine problems, and several diagnostic test are demonstrated. The operation of computer controlled systems is also covered. VHS, 112 min.

- *The Fuel System* from *The Basic Engine* videotapes. *The Basic Engine* videotapes present a thorough introduction to the internal combustion engine. Other titles are: *The Four-Stroke Cycle Internal Combustion Engine, Engine Components, Valve Mechanisms and the Two-Stroke Cycle,* and *The Lubricating and Cooling Systems.* 3 videos from filmstrips.

The following videos are available from Vocational Media Associates, Box 1000, Mount Kisco, NY, 10549-0010. 800-431-1242.

- *Air and Vapor Pollution Controls.* Air injection system, air temperature control systems, fuel vapor control systems, intake manifold heat control. VHS, 60 min.

- *The Basic Engine. The Four-Stroke-Cycle Internal Combustion Engine* demonstrates how the parts of a typical engine interact. *Engine Components* describes the function of the crankshaft, the piston rings, cam shaft, and valves. *Valve Mechanisms and the Two-Stroke-Cycle* covers valve seats through valve trains, and two- and four-stroke diesel engines. *The Fuel System* explains gasoline flow, fuel pumps and filters, including calculation of air-fuel ratios. Discusses emission control. *The Lubricating and Cooling Systems* shows reduction of friction and heat dispersal. Discusses types of motor oil. Illustrates components of air- and liquid-cooled engines. VHS, 5 parts, 85 min. with teacher's guide or filmstrips.

- *The Basics of Automobile Computer Control Sensors. How the Coolant Temperature Sensor Works* defines the role of the sensor in controlling fuel delivery, ignition timing, idle speed and exhaust gas recirculation. *How the Knock Sensor Works* examines how the computer uses the signal from the sensor in dealing with ignition timing control and shows how a basic diagnostic test is made. *How the MAP and BARO Sensors Work* explains the job of MAP and BARO sensors in maintaining good engine performance and illustrates how sensors signal the computer. *How the Oxygen Sensor Works* discusses how the air-fuel mixture affects the sensor and explains the way in which the sensor signals the computer. *How the Throttle Position Sensor Works* explains how the computer reacts to the information and illustrates how the fuel supplied to the engine's intake is affected. 5 VHS tapes, teacher's guide.

- *The Battery and Its Electrical System.* Help your students learn how to install a battery and service an electrical system in this colorful live-action video. The program demonstrates battery activation and installation and shows how to test the starter, voltage regulator and alternator. It also explains how and why there are differences in battery quality. VHS, 17 min., teacher's guide.

- *Computer Control: Ford and GM.* Here's an opportunity to find out the fundamental concepts and the hands-on information for today's computerized engines. *Basic Diagnostic Testing (Ford)* introduces Ford's service manual, describes how to inspect the car, and shows how to get basic diagnostic information from the car's computer. *Basic Diagnostic Testing (GM)* describes the advantage of the self-diagnostic capability of the CCC system, explains the role of the ECM, shows how to activate the system, illustrates how the service code is displayed, shows how to use the service code, and emphasizes the importance of manufacturers' manuals in the repair process. *GM Computer Command Control System (CCC)* provides an overview of CCC, explains how the driver is warned of engine failure, describes the ECM and its components, and details where sensors and controls are located. *Ford Engine Electronic Control System (EEC)* defines the EEC system, describes sensors, switches and actuators, compares the Ford EEC to other systems, and shows how to troubleshoot sensors and controls. VHS, 52 min., teacher's guide.

- *The Computer in the Automobile: Systems and Components. Evolution and Applications* describes the progress from manual choke through computer-controlled fuel injectors. Explores the benefits of a computer-controlled system over a manual one. *Integrated Circuits: the Computer's Brain* provides an inside look at some of the integrated circuits and how they work. Relates integrated circuits to the computer's complex decision-making process. *On-Board*

Computer Vocabulary defines terms specifically associated with on-board computer systems. *Test Equipment* illustrates digital and analog equipment and self-test features on some computer systems. *The System and Its Components* introduces sensors and controls and shows how they work together to manage many engine functions. Relates sensors and controls to the computer. 5 VHS tapes, teacher's guide.

- *Electronic Fuel Injection: Basic Systems and Troubleshooting.* Explains the function and operation of fuel injector systems by illustrating components. Describes how to troubleshoot a no-fuel condition. Includes instructions for replacing a filter. Explains tests that can be done in the shop or on the road. 60 min. Video.

- *Engine Computer Testing Procedures. Self-Testing* illustrates safety precautions. Describes the use of trouble codes as a diagnostic tool. Demonstrates a self-test. *Pinpoint Testing* defines trouble codes. Outlines preliminary procedures for pinpoint testing. Discusses diagnostic charts. *Sensor Testing and Service* includes testing and service of EGO sensor, mixture control or MC solenoid and throttle position solenoid. Defines actuator resistance and programmable read-only memory. VHS, 45 min.

- *Engine Diagnostic Procedures. Preliminary Diagnostic Inspection* demonstrates the typical inspection procedure, shows how to conduct a comprehensive visual inspection and sound, smoke-color and odor analysis. *Vacuum and Power Balance Testing* demonstrates cranking vacuum and speed testing, PCV quick testing, manifold vacuum testing and power balance testing. *Cylinder Compression and Cylinder Leakage Testing* demonstrates the basic compression test, wet compression test and cylinder leakage test, compares test results with power balance test. *Engine and Exhaust Gas Analyzers* introduces typical engine analyzer, outlines four main sections: oscilloscope, CRT-diagnostic computer, pneumatic section and infrared exhaust gas analyzer. 4 part VHS, 60 min., teacher's guide.

- *Engine Performance and Tune-Up: A Video Manual.* As a complete video tune-up manual, this live-action video covers basic ignition theory, service procedures, and troubleshooting techniques. Diagrams, working models, and cutaways are used for an in-depth exploration of ignition system theory. This provides a basis for understanding the tune-up procedures that follow. Some of the tune-up procedures shown include component replacement (points, ignition modules, and filters), timing and dwell adjustment, and carburetor adjustments. This program covers service procedures performed on four, six, and eight-cylinder engines of many makes and years. It provides the in-depth instruction of repair manuals combined with the clarity of the video image. Whether you want to perform a basic tune-up or learn how to interpret oscilloscope patterns and understand computer systems, this tape is for you. VHS, 98 min., teacher's guide, library kit.

- *Engine Troubleshooting: Testing and Procedures Series; Engine Diagnostic Procedures.* Cylinder compression and cylinder leakage testing; Engine and exhaust gas analyzers; Preliminary diagnostic inspection, vacuum and power balance testing. VHS, 60 min., teacher's guide.

- *Exhaust and Crankcase Pollution Controls.* Positive crankcase ventilation and exhaust gas recirculation. VHS, 30 min.

- *Exhaust System Testing and Service.* Two sections include: *Exhaust System Service* and *Catalytic Converter Inspection.* VHS, 30 min.

- *Finding the Problem; Troubleshooting On-Board Computer Systems. Basic Checking Procedures* illustrates step-by-step procedure for checking the computer before using the equipment. Focuses on electrical wires, vacuum lines and connections. *Introduction to Diagnosing a Computer System Malfunction* reinforces the importance of utilizing the computer system's self-test capabilities. Introduces test procedures. *Troubleshooting Computer System Controls* explains how to check fuel, ignition, and exhaust system controls. Shows how to identify malfunctions and how to do performance tests. *Troubleshooting Sensors* highlights conditions that result when a sensor malfunctions. Focuses on oxygen, map, and coolant temperature sensors. Shows how sensors are tested. VHS, 40 min., teacher's guide.

- *Fuel Delivery and Induction Systems: Testing and Service.* 4 videos.

- *Fuel Delivery Systems. Fuel Storage Inspection* and *Fuel Pump and Filter Inspection.* 30 min. video.

- *Fuel Injection System Service.* Part 1: *Port Fuel Injection Systems.* Part 2: *Throttle Body Fuel Injection Systems.* 30 min. video.

- *Fuel System* section from the *Basic Engine* video. Covers the four-stroke cycle internal combustion engine, the engine components, the valve mechanisms and two-stroke cycle, the fuel system and the lubricating and cooling systems. 85 min. video.

- *How the Automobile Works.* Includes a detailed look at six systems: cooling, ignition, drive train, electrical, steering and suspension, and air conditioning system. Explains servicing procedures. VHS, 90 min.

- *How Cars Work: A Video Manual.* Titles included are: *The Electrical System, The Cooling System, The Brake System,* and *The Emissions Control System. The Electrical System* illustrates the major components. Explains the function of the battery, alternator, switches, lights, wires and fuses. Demonstrates how they interact within the system. *The Cooling System* describes the importance of the system. Demonstrates how the radiator, water pump, thermostat, hoses, and coolant work. Explains how the components work together to control engine temperature. *The Brake System* illustrates components. Shows the difference between drum brakes and caliper brakes. Explains how hydraulic systems work. Describes brake support systems. *The Emissions Control System* demonstrates how parts of the system interact to monitor and control ignition and fuel delivery. Explains how the system maintains discharge of exhaust emissions. Shows how malfunctions can affect engine performance. VHS, 60 min, teacher's guide and library kit.

- *Troubleshooting Electronic Fuel Injection (EFI).* Program explains the Ford EFI system and the GM EFI system. Describes how to troubleshoot a no-fuel condition. Includes instructions for replacing a filter. Explains tests that can be done in the shop or on the road. 56 min. video.
- *Troubleshooting with Electronic Test Equipment. Setting Up the Allen Analyzer For a Test.* Explains features of the analyzer. Shows how to set up and connect it to the engine. *The Allen Engine Analyzer: Running a Test.* Illustrates the Allen Smart Engine Analyzer. Describes using the analyzer to make basic tests. *The Brainmaster Universal Computer System Tester.* Shows how the analyzer is set up and used to test various computer system sensors. Includes Ford, Chrysler, and GM vehicles. *The Sun Interrogator: Hooking Up and Basic Testing.* Shows how to connect the Interrogator to the engine. Illustrates basic tests. *The Sun Interrogator: Identification and Program Setup.* Identifies features. Sets up a problem in preparation for a test. *Using OTC Computer Test Equipment.* Illustrates the hand-held OTC automotive computer system analyzer. Explains how to check a GM vehicle computer system. 6 VHS tapes, 60 min., teacher's guide.
- *Troubleshooting Exhaust and Emission Control Systems.* 3 VHS tapes.
- *Turbocharger Testing and Service.* Includes *Testing Procedures* and *Servicing Procedures.* 30 min. video.
- *Understanding Electronic Ignition Service. Servicing the Ford Electronic Ignition Distributor* explains how to remove the distributor from the engine. Identifies components. Describes cleaning and checking for proper operation. *Troubleshooting the Ford Electronic Ignition Distributor* uses a six-cylinder Ford as a demonstration model. Shows how to use a voltmeter and an ohmmeter. *Servicing the Chrysler Electronic Ignition System* follows the procedure for removing and disassembling the distributor. Describes checking, cleaning, and replacing a distributor. *Troubleshooting the Chrysler Electronic Ignition System* uses a six-cylinder Chrysler as a demonstration model. Reviews basic procedures. *Servicing the GM Electronic Ignition Distributor* follows procedures for removing and disassembling the distributor. Uses a six-cylinder high energy ignition distributor as a model. Describes cleaning, and checking parts. *Troubleshooting the GM Electronic Ignition System* describes testing the spark, checking the battery voltage, the cap, coil, rotor, vacuum unit, pick-up coil and module. VHS, 6 parts, 65 min., teacher's guide.
- *Understanding the Turbocharger.* Describes the unit and how to analyze a malfunction. Illustrates how to disassemble the unit, rebuild the center housing and rotating assembly. Ends with the step-by-step procedure for reassembling the entire unit. 56 min. video.

The following videcs are available from Vocational Marketing Services, 17600 South Williams Street, #6, Thornton, IL, 60476-1077. 800-343-6430.

- *Automotive Computer Self-Diagnosis.* Summarizes how to read computer trouble codes, Ford, General Motors, Chrysler and other makes are discussed so the student knows how to trigger self-diagnosis without using a scan tool. VHS, 25 min.

- *Automotive Computer System Operation.* Makes a complex computer system seem simple with easy to understand language and computer generated artwork. How a computer system uses information from sensors to control the operation of other devices and systems. Sensors and actuators divided into basic categories. VHS, 25 min.

- *Automotive Computer System Service.* Shows how to do basic tests and repair procedures on a computer system: the problem sources, symptoms, tests, and repairs need to fix common malfunctions. VHS, 25 min.

- *Cooling System Repairs.* Cooling system failures are one of the leading causes of roadside breakdowns. This tape shows: cooling system operation, testing antifreeze protection, cooling system flushing, electric fan installation, and replacement of V and multi-ribbed belts, heater/radiator hoses, thermostat, water pump, fan clutch, heater core. VHS, 55 min.

- *Gasoline Injection System Operation.* Explains the operation of an electronic fuel injection system. Generic information applies to all makes/models of cars. 25 min. video.

- *Scanning Automotive Computer Problems.* A follow-up to *Computer Self Diagnosis* shows how to use several types of scanning tools to analyze difficult to locate computer system problems. General scanner use, computer electrical values, and modem type analysis systems shown. VHS, 25 min.

- *Starting and Charging System Repairs.* Starting and charging systems work together to get the car or truck started and keep it running. Keeping both systems in proper working condition will ensure quick starts all year round. Shows: how to understand car battery ratings, battery condition testing, battery care and replacement, correct jump starting procedures, alternator and starter replacement, and much more. VHS, 40 min.

- *Using a Load Tester.* Shows how to use typical load testers. Battery, alternator, starter, and other tests are demonstrated on analog and digital load testers. Animation shows what is happening inside the tester and circuit. VHS, 25 min.

Engine Performance Specialist

Instructional Supplement

Reading

Science

Creative Thinking/ Problem Solving

Writing

Oral Communication

Employability

Math

Interpersonal or Relating

Social Studies

Reading Comprehension

- If students have difficulty drawing conclusions:
    - Remind students that when they analyze a situation, perform a job task, or even discuss a television show or movie, they will often be asked to demonstrate understanding by telling what happened and explaining why it happened.
    - Provide opportunities for students to practice drawing conclusions by describing events, such as a group of people crowded around a table that has a decorated cake with lighted candles on it, and asking them to decide what is happening. Have them explain why they reached that conclusion.
    - Provide opportunities for students to practice drawing conclusions. Present students with descriptions of events, or with photographs or drawings, and ask them to describe what is happening. Ask the student(s) to support each response.
    - Remind students that before they can draw conclusions, they must carefully observe what is happening and think about why it is happening. In more complex situations, it is often a good idea to take notes about possible conclusions as you work.

Research and Reference

- If students have difficulty selecting useful resources:
    - Review the different types of resources available to students. Have volunteers tell what kind of information can be found in each resource type. Have them discuss the types of projects on which each resource can assist.
    - Help students learn how to locate each resource in libraries, resource centers, or media centers.
- If students have difficulty using standard references:
    - Review the purpose(s) of the specific reference work. Give examples of situations and the reference appropriate for each.
    - Illustrate the proper use of each reference work. Have students practice using each reference in a task-specific situation.

- If students have difficulty using in-book reference tools:

    - ☐ Identify the in-book reference tools in a specific reference work: table of contents, index, glossary, appendices, tabs, color codes, list of figures, list of tables, list of symbols, maps, "how to use this book" pages, and others.

    - ☐ Illustrate the proper use of each in-book reference tool. Have students practice using each tool in a task-specific situation.

Functional Reading

- If students have difficulty following written instructions:

    - ☐ Discuss the possible consequences of not following instructions precisely.

    - ☐ Review the *importance* of following written instructions. Give appropriate scenarios when written instructions are not followed or are not followed completely and correctly.

    - ☐ Discuss the *relationship* between the order of written instructions and the appropriate outcome. Emphasize the need to follow written instructions in their proper order. Use examples where the order of instructions in a sequence is critical to the outcome of the task.

    - ☐ Explain to students that one of the keys to following written directions successfully is to read the directions completely before actually beginning to follow them. Doing this ensures that you will not be surprised as you work through the steps. It also gives you an opportunity to ask questions about steps you do not understand.

    - ☐ Tell students that, after they have read the directions and understand what to do, they should go back to Step 1 and follow the directions step-by-step (without skipping any steps). Remind students that it is important to follow steps in order, even if they think they already know what to do.

- If students have difficulty interpreting graphics and symbols:

    - ☐ Remind students that interpreting a graphic is very similar to reading a page. Each part of the graphic or symbol has a meaning within the art.

    - ☐ Suggest that, when they have a graphic, chart, diagram, or table to interpret, they should carefully study the art and compare it to any similar pieces encountered. They should also study the key or any other information that will help in understanding the graphic.

    - ☐ Review the symbols being used. Discuss the purposes for each symbol. Discuss the importance of memorizing the symbols.

    - ☐ Discuss sample graphics and the purposes for each. Create or locate other examples of graphics and ask students to interpret them.

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  - Explain the importance of correctly interpreting graphics and symbols. Describe possible consequences of incorrect interpretations.

- If students have difficulty using content area vocabulary:
  - Remind students that nearly every occupation or group uses words that have specific, specialized meanings to others in the same occupation or group. Have them name and define some content area, technical, or "slang" words with which they are familiar.
  - Explain that using content area or technical words makes it easier for people within groups or occupations to communicate ideas accurately. Remind students that often the same word may have a generic meaning to the majority of people, but a very specific meaning within an industry.
  - Review key terms and concepts, so that students hear, see, write, and say them.
  - Have students suggest ways to learn the meanings of the vocabulary specific to what they are studying. Provide opportunities for students to practice using the terminology they will need.
- If students have difficulty interpreting abbreviations/acronyms:
  - Present examples of appropriate abbreviations and/or acronyms. Use actual examples from specific sources, such as newspapers, books, and others.
  - Ask students to interpret the examples. Give hints, if needed.

Math Application

- If students have difficulty using English and metric measures:
  - Review the metric system.
  - Provide students with conversion tables.
  - Provide students with English and metric liquid and linear measuring instruments. Have them make measurements with each system and compare the differences.

Data Analysis and Display

- If students have difficulty collecting/recording data:

  - Suggest that students first decide how the data will be collected and recorded. Explain that it is always best to come prepared with pencil or pen and a preplanned sheet for recording the specific data that will be collected. This preparation allows you to devote careful attention to your work.
  - Stress the importance of accuracy in recording data. Review any appropriate symbols, abbreviations, and other tools.

Functional Math

- If students have difficulty making measurements:
  - Remind students that a key to making accurate measurements is to understand the techniques used for the type of measurement being made.
  - Suggest that students ask questions such as: How should the measurement be recorded (nearest inch)? What should be used to make the measurement? Are there special instructions that should be followed? Understanding what is expected and what must be learned makes the measuring task easier.
  - Review what is to be measured, the tools to be used, and any special instructions to be followed. Allow students time to practice using and reading the tool or measuring device.
  - Review the units of measure in the English and metric systems, if appropriate.
  - Demonstrate the correct procedure for making the required measurement(s).

General Science

- If students have difficulty using scientific instruments:
  - Discuss, demonstrate, and review the procedures. Provide more opportunities for students to practice using the instrument..
- If students have difficulty investigating/applying technology:
  - Review characteristics and functions of the technology being used. Ask students if they know how the task was performed prior to this technology. Have them discuss possible new technologies on the horizon.
  - Discuss the uses of the technology in today's society. Has this technology changed the job market and requirements for employment in the industry?

Physical Science

- If students have difficulty investigating/applying physical laws:
    - Review the definition of physical science. Have students give examples of physical sciences.
    - Divide class into two or three groups. Have each group conduct simple experiments to demonstrate physical or chemical changes or to demonstrate physical laws.

Interactive Communications

- If students have difficulty applying questioning techniques:
    - Remind students to plan in advance what they want to ask during an interview by deciding what they need to learn from the interview.
    - Explain that it is always good to have a written list of the questions to be asked, so that important questions are not omitted. Give examples of such questions.

Teamwork/Cooperative

- If students have difficulty selecting/applying appropriate behavior:
    - Discuss the meaning of "appropriate behavior."
    - Divide the students into small groups. Give each a situation, and have them determine and act out appropriate behavior for that particular situation.

Cognitive Activities

- If students have difficulty identifying critical elements/issues:

- Instruct students to read or examine their sources carefully, noting key words and ideas.
  - Suggest they list the questions they hope to answer.

- If students have difficulty drawing conclusions:
  - Remind students that when they conduct an experiment, perform a job task, or discuss a subject, they will often be asked to draw conclusions. Give examples of such situations.
  - Explain that, before conclusions can be drawn, students must first observe carefully what is happening and why it may be happening. Suggest that, with complex experiments, a good set of notes taken while conducting the experiment can help in drawing conclusions.
  - Have students practice drawing conclusions. When possible, choose situations appropriate for the occupation or subject (such as an actual experiment, etc.). Or, use a general situation using photographs or a videotape without the volume. Ask students to state what is happening in each picture (their conclusion). Have students support their conclusions.

- If students have difficulty devising a solution:
  - Review the critical elements/issues of the problem.
  - Review the definition of the problem.
  - Review the goals for solving the problem.
  - Discuss the alternative they have chosen to solve the problem.

- If students have difficulty transferring knowledge/training to new situations:
  - Remind the students that everything they do makes use of information that they already know. Tell them that this process of using known information often happens subconsciously. When you identify an animal as a dog, you use already known information—you know what dogs look and act like so you can recognize a dog.
  - Tell the students that when they encounter a situation or a question they aren't familiar with, they should examine it carefully to identify what they already know that will help them solve the problem or answer the question. For practice, use examples such as the following:
  - A baby you are caring for starts crying. You don't know why, but you do want to make her stop. How do you know what to try? Begin by thinking carefully about what you know about why babies cry. (hungry, diaper needs changing, wants attention, sick) Identifying what you already know gives you ideas to try that might make the baby stop crying.

  - Remind the students that when trying to solve a problem or answer a question, they should always identify what they know by thinking about similar situations, problems, or questions they have faced. This will help them with find the answer.

Job Acquisition/Development

- If students have difficulty mastering specific job task/procedure:
  - Discuss the importance of mastering specific job tasks or procedures. Explain that it is probably impossible to find a job where there isn't a task or procedure to be mastered. Remind them that future employers will be more likely to hire people who can already perform the tasks required.
  - Ask the students to share methods they have used to master specific job tasks or procedures. Discuss these methods with the class.
  - Emphasize the fact that practice makes a person proficient and proficiency makes a person confident.
  - Suggest they study each component of the procedure to determine which area is causing difficulty.
  - Review the entire procedure.
  - Team them with proficient students or professionals to practice the procedure.
- If students have difficulty practicing good work habits/attitudes:
  - Remind the students that future employers are looking for people with good work habits. Have the students list what they think are good work habits. Discuss each suggestion as it is named. Have them identify ways to improve work habits.
  - Distinguish between habits and attitudes. Demonstrate how it is possible to have good work habits, but a poor attitude.
  - Explain the role of good work habits and attitudes in obtaining and retaining employment.
  - Distinguish between good and poor work habits and attitudes. Give examples.
  - Discuss the employer's expectations of the student on the job.

INSTRUCTOR'S GUIDE

UNDERSTANDING ENGINE FUNDAMENTALS

1

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read "The Charging System" in the December 1993 issue of *Hot Rod* magazine.

Writing

R Have the students write a short (one paragraph to one page) description of the causes and symptoms of fouled spark plugs.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1

List safety hazards associated with engine performance work.

R Lead a discussion about the safety hazards listed. Include information on the sources of the hazards and how best to avoid them.

OBJECTIVE 2

List automotive sources related to engine service which contain hazardous chemicals.

R Explain the chemicals on the list, what to avoid (skin contact, fumes, etc.) when around the chemical, what symptoms you might experience, and what emergency measures should be taken if you come in contact with the chemical.

O Have the students take notes on your explanation and then quiz them on the information.

OBJECTIVE 3 **List the names of engine systems.**

OBJECTIVE 4 **Describe the functions of engine systems.**

R Explain the functions of the engine systems and how it is necessary that they work together to keep the engine functioning properly.

R Point out the components of the different engine systems on a vehicle.

OBJECTIVE 5 **List three elements that must be present in order for combustion to occur.**

OBJECTIVE 6 **List the four strokes of an internal combustion engine in the order of their occurrence.**

R Use transparency 1 to help you explain what happens inside the engine during each of the four strokes.

O Use a model of an engine cylinder to help you explain the four strokes.

OBJECTIVE 7 **Using illustrations of cylinders, sketch the spark in the correct engine stroke.**

R Use transparency 2 to help you explain engine timing as it relates to the power stroke of a four stroke engine.

R Project transparency 2 or distribute the Handout so the students can draw their sketches showing the spark in the correct stroke. Check the students' drawings to make sure they are correct.

OBJECTIVE 8 **Using illustrations of cylinders, sketch the piston in the correct position for each of the four engine strokes.**

R Explain the terms in the Words You Should Know box.

R Project transparency 3 or distribute the Handout so the students can draw their sketch showing the piston in the correct position for each of the four engine strokes. Check the students' drawings to make sure they are correct.

OBJECTIVE 9

Using illustrations of cylinders, draw an arrow to indicate the direction of piston movement for each of the four engine strokes.

R Project transparency 4 or distribute the Handout so the students can draw their sketches showing an arrow indicating the direction of piston movement for each of the four engine strokes. Check the students' drawings to make sure they are correct.

OBJECTIVE 10

Using illustrations of cylinders, sketch the intake valve in the correct position for each of the four engine strokes.

R Project transparency 5 or distribute the Handout so the students can draw their sketches showing the intake valve in the correct position for each of the four engine strokes. Check the students' drawings to make sure they are correct.

OBJECTIVE 11

Using illustrations of cylinders, sketch the exhaust valve in the correct position for each of the four engine strokes.

R Project transparency 6 or distribute the Handout so the students can draw their sketches showing the exhaust valve in the correct position for each of the four engine strokes. Check the students' drawings to make sure they are correct.

OBJECTIVE 12

List the names of emission control systems.

O Have the students give oral reports on each of the emission control systems listed.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.

- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.

- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.

- Complete the appropriate sections of the Competency Profiles.

- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The item marked with an asterisk is included in the Instructor's Resource Package.

Publications

- "The Charging System." *Hot Rod*, December 1993.
- *Four Strokes of an Internal Combustion Engine*. Handout. *

OPTIONAL REFERENCES

Publications

- *Measuring Learning and Competency Gains: the Pretest/Posttest Approach*. Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 74074-4364, or call 800-522-5810, 1992.

UNIT REFERENCES

Publications

- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, OH: South-Western Publishing Co., 1986.
- *Engine-Chassis-Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles.* Chrysler Corp., 1985.
- *Mitchell Automechanics.* Mitchell Information Services. Englewood Cliffs, NJ: Prentice-Hall, 1986.
- Toboldt, William K., and Larry Johnson. *Automotive Encyclopedia*. South Holland, IL: Goodheart-Willcox Co., Inc., 1983.
- *Understanding Emission Controls.* Ford Parts and Service Division Training and Publications Dept., 1986.
- Webster, Jay. *Auto Mechanics*. Encino, CA: Glencoe Publishing Co., Inc., 1980.

ANSWERS — UNDERSTANDING ENGINE FUNDAMENTALS 1

WRITTEN TEST

OBJECTIVE 1

Answer should include the following information in any order:

- cuts
- electrical shock
- exposure to toxic chemicals
- muscle strains

OBJECTIVE 2

Answer should include the following information in any order:

- antifreeze
- battery acid
- carburetor cleaners
- compounds used to free valve lifters
- exhaust gases
- gasoline additives
- gum and carbon removal compounds
- leaded gasoline
- solvents

OBJECTIVE 3

Answers should include the following information in any order:

- starting system
- ignition system
- fuel system
- lubrication system
- cooling system
- exhaust system
- charging system

OBJECTIVE 4

Answers should include the following information in any order:

- starting system – starts the engine
- ignition system – provides the spark to burn the fuel
- fuel system – supplies fuel to the engine
- lubrication system – reduces friction and cleans the engine
- cooling system – cools the engine
- exhaust system – removes unburned fuel and exhaust from the engine
- charging system – provides electrical power to the ignition system and charges the battery

OBJECTIVE 5

Answers should include the following information in any order:

- fuel
- air
- heat

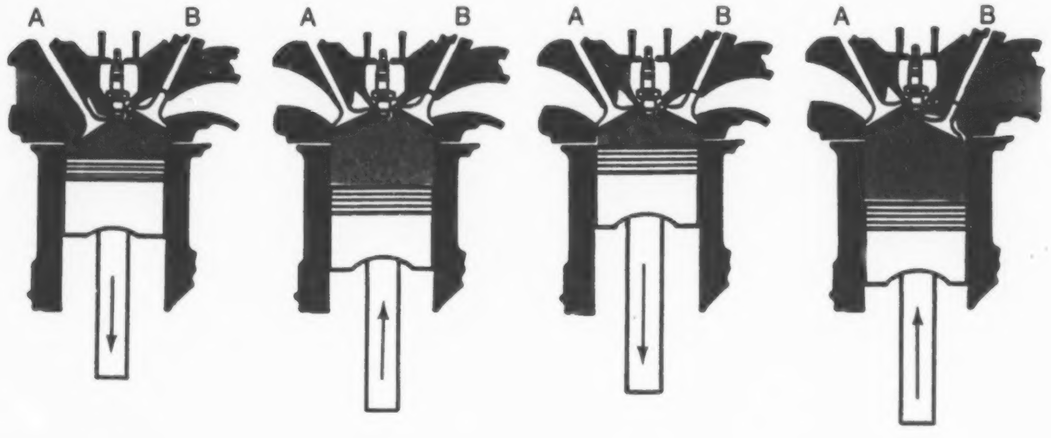
OBJECTIVE 6

This list may begin with any stroke, but the next stroke listed must be the one that would follow it in order of occurrence.

1. intake
2. compression
3. power
4. exhaust

OBJECTIVE 7

The spark should be in the position shown below.



Intake Compression Power Exhaust

OBJECTIVE 8

The pistons should be in the positions shown in objective 7 on the previous page.

OBJECTIVE 9

The arrows indicating the direction of piston movement should be in the directions shown in objective 7 on the previous page.

OBJECTIVE 10

The intake valves should be in the positions shown by the letter "A" in objective 7 on the previous page.

OBJECTIVE 11

The exhaust valves should be in the positions shown by the letter "B" in objective 7 on the previous page.

OBJECTIVE 12

Answers should include the following information in any order:

- air injection system
- exhaust gas recirculation system
- fuel vapor control system
- heated air induction system
- manifold heat control system
- positive crankcase ventilation system

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE **1** — UNDERSTANDING ENGINE FUNDAMENTALS

TOTAL NUMBER OF TEST QUESTIONS **60**

TOTAL NUMBER OF BASIC SKILL QUESTIONS **40**

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1-4	T
2	1-9	T
3	1-7	X
4	1-7	X
5	1-3	T
6	1-4	S
7	1-4	S
8	1-4	S
9	1-4	S
10	1-4	S
11	1-4	S
12	1-6	X

INSTRUCTOR'S GUIDE

SERVICING STARTING AND CHARGING SYSTEMS

2

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have students read about how to keep an automobile battery in working order in John Kirk's article, "Keeping Batteries Charged," in *Home Mechanix* magazine, October 1992, pp. 32 and 36.

Writing

R Ask students to write a short (one page) description of the charging system, particularly including ways to detect any problems before they occur. Have them include any measures that can be taken to prevent excessive drain on the battery.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **List safety rules for working with automobile batteries.**

OBJECTIVE 2 **List factors affecting correct battery selection.**

R Explain the factors that affect the correct selection of a battery.

OBJECTIVE 3 **Select the appropriate battery to meet starting system needs. (Assignment Sheet 1)**

R Explain the material in Handouts 1 and 2 and Information Sheet, objective 2.

R See the general instructions for all Assignment Sheets.

OBJECTIVE 4 **Inspect, service, and replace a battery. (Job Sheet 1)**

R See the general instructions for all Job Sheets.

OBJECTIVE 5 **Perform a battery load test. (Job Sheet 2)**

R See the general instructions for all Job Sheets.

OBJECTIVE 6 **Slow and fast charge a battery. (Job Sheet 3)**

R See the general instructions for all Job Sheets.

OBJECTIVE 7 **Label the parts of a starting system indicated on an illustration.**

R Use transparency 1 to help you explain how the parts work together in starting system operation.

OBJECTIVE 8 **Match the names of the parts of a starting system to descriptions of their functions.**

R Show parts of an actual starting system as you explain the function of each part.

OBJECTIVE 9 **Arrange the steps of starting system operation in order.**

OBJECTIVE 10 **List the components tested by starting/charging system tests.**

OBJECTIVE 11 **Match the names of starting/charging system tests with descriptions of the conditions evaluated by the tests.**

R Explain the conditions evaluated by starting/charging system tests.

OBJECTIVE 12

Describe how starting/charging test equipment is hooked up to the vehicle.

R Show the students how to hook up the test equipment.

OBJECTIVE 13

Perform a starter current draw test. (Job Sheet 4)

R See the general instructions for all Job Sheets.

OBJECTIVE 14

Perform voltage drop tests. (Job Sheet 5)

R See the general instructions for all Job Sheets.

OBJECTIVE 15

Inspect, test, and repair or replace components and wires in the starter control circuit. (Job Sheet 6)

R See the general instructions for all Job Sheets.

OBJECTIVE 16

Diagnose starting system problems. (Assignment Sheet 2)

R Explain the material in Handout 3.

R See the general instructions for all Assignment Sheets.

OBJECTIVE 17

State the purpose of a charging system.

OBJECTIVE 18

Label the parts of a charging system indicated on an illustration.

R Use transparency 2 to illustrate the parts of a charging system as you describe the operation of the system.

OBJECTIVE 19

State the purpose of an alternator.

R Explain how an alternator operates.

OBJECTIVE 20

Inspect, adjust, and replace alternator drive belts, pulleys, and fans. (Job Sheet 7)

R See the general instructions for all Job Sheets.

OBJECTIVE 21

Inspect, repair, and replace charging circuit connectors and wires. (Job Sheet 8)

R See the general instructions for all Job Sheets.

OBJECTIVE 22

Diagnose charging system problems that cause an undercharge, overcharge, or a no-charge condition. (Assignment Sheet 3)

R Explain the material in Handout 4.

R See the general instructions for all Assignment Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.
- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.
- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.
- Reteach and retest as necessary.
- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The items marked with an asterisk are included in the Instructor's Resource Package.

Publications

- *Charging System Diagnosis Chart*. Handout 4.*
- *Choosing a New Battery*. Handout 1.*
- *Estimated Battery Drain of Vehicle Optional Equipment*. Handout 2.*
- Kirk, John. "Keeping Batteries Charged." *Home Mechanix*, October 1992, pp. 32 and 36.
- *Starting System Diagnosis Chart*. Handout 3.*

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach.* Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 1992. For ordering information call 800-522-5810.

UNIT REFERENCES

Publications

- Bono, Saverio G. and William J. deKryger. *Auto Technology.* Albany, NY: Delmar Publishers Inc., 1990.

  —. *Auto Technology Student Service Manual.* Albany, NY: Delmar Publishers Inc., 1990.

- Crouse, William and Donald Anglin. *Automotive Mechanics.* Westerville, OH: Glencoe Publishing Co., 1993.

- Derato, Frank. *Automotive Electrical and Electronic Systems.* Westerville, OH: Gregg Division, Glencoe/McGraw-Hill, 1990.

  —. *Automotive Electrical and Electronic Systems Shop Manual.* Westerville, OH: Gregg Division, Glencoe/McGraw-Hill, 1990.

- *Engine Performance Testing.* General Motors Corp., 1987.

- Erjavec, Jack. and Robert Scharff. *Automotive Technology.* Albany, NY: Delmar Publishers Inc., 1992.

  —. *Tech Manual to Accompany Automotive Technology.* Albany, NY: Delmar Publishers Inc., 1992.

- John Deere Service Publications. *Fundamentals of Service – Electrical Systems.* Moline, IL: Deere and Co., 1982.

- Kirk, John. "Keeping Batteries Charged." *Home Mechanix,* October 1992, pp. 32 and 36.

- Layne, Ken. *Automotive Engine Performance.* Englewood Cliffs, NJ: Prentice Hall, 1986.

- *Maintenance-Free Batteries, Charging and Starting Systems.* General Motors Corp., 1987.

- *Technical Specifications – Batteries, Charging, and Cranking.* General Motors Corp., 1987.

ANSWERS

SERVICING STARTING AND CHARGING SYSTEMS

2

ASSIGNMENT SHEETS

OBJECTIVE 3

Assignment Sheet 1

1. B
2. No
3. 480 CCA
4. D
5. B
6. A
7. Answers will vary, but the instructor should have given a sufficient number of examples in the discussion in the introduction to the Assignment Sheet for the students to answer this question.
8. A
9. Yes
10. True

OBJECTIVE 16

Assignment Sheet 2

1. B
2. B
3. B
4. A
5. B
6. B
7. B
8. B
9. D
10. D

OBJECTIVE 22

Assignment Sheet 3

1. B
2. A
3. D
4. B
5. A
6. D
7. D

WRITTEN TEST

OBJECTIVE 1

Answers should include the following information in any order:

- Always wear safety glasses, rubber gloves, and a rubber apron when working with batteries.
- Always keep a mixture of baking soda and water nearby when working with batteries.
- Do not smoke near a battery on charge or near recently charged batteries.
- Do not break live circuits at the battery.

OBJECTIVE 2

Answers should include the following information in any order:

- Manufacturer's recommended battery size
- Battery Council International (BCI) rating
- Temperature of the surroundings in which vehicle will operate
- Electrical options added before and after market
- Whether or not the vehicle has air conditioning

OBJECTIVE 3

Evaluated on Assignment Sheet 1.

OBJECTIVE 4

Evaluated on Job Sheet 1.

OBJECTIVE 5

Evaluated on Job Sheet 2.

OBJECTIVE 6

Evaluated on Job Sheet 3.

OBJECTIVE 7

1. Battery
2. Ignition switch
3. Starter
4. Solenoid

OBJECTIVE 8

1. C
2. A
3. B
4. D

OBJECTIVE 9

2, 1, 3

OBJECTIVE 10

Answers should include the following information in any order:

- alternator
- battery
- starter
- wiring and switches

OBJECTIVE 11

1. E
2. A
3. B
4. D
5. C

OBJECTIVE 12

1. The ammeter pickup is clamped around the positive battery cable.

2. The multimeter probes are placed in the test circuit on either side of the load being tested.

3. After the wire or component being tested has been disconnected from a source of voltage, the multimeter probes are placed on either side of the wire or component being tested.

4. The multimeter probes are placed in the test circuit between the power source and the load.

5. The rubber tube or stick end of the hydrometer is placed into the electrolyte fluid inside the battery.

6. The leads are connected to the positive and negative battery terminals.

OBJECTIVE 13

Evaluated on Job Sheet 4.

OBJECTIVE 14

Evaluated on Job Sheet 5.

OBJECTIVE 15

Evaluated on Job Sheet 6.

OBJECTIVE 16	**Evaluated on Assignment Sheet 2.**
OBJECTIVE 17	The purpose of a charging system is to restore the battery's electrical charge.
OBJECTIVE 18	1. alternator 2. wiring harness 3. drive belt 4. ground straps 5. battery 6. voltage regulator 7. cables
OBJECTIVE 19	The purpose of an alternator is to convert mechanical energy from the operation of the engine into the electrical energy required to restore the electrical charge of the battery.
OBJECTIVE 20	**Evaluated on Job Sheet 7.**
OBJECTIVE 21	**Evaluated on Job Sheet 8.**
OBJECTIVE 22	**Evaluated on Assignment Sheet 3.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 2 — SERVICING STARTING AND CHARGING SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 44

TOTAL NUMBER OF BASIC SKILL QUESTIONS 25

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1-4	E
2	1-5	T
3	Evaluated on AS 1	
4	Evaluated on JS 1	
5	Evaluated on JS 2	
6	Evaluated on JS 3	
7	1-4	X
8	1-4	X
9	1-3	S
10	1-4	X
11	1-5	S, T
12	1-6	W, T
13	Evaluated on JS 4	
14	Evaluated on JS 5	
15	Evaluated on JS 6	
16	Evaluated on AS 2	

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 2 — SERVICING STARTING AND CHARGING SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 44

TOTAL NUMBER OF BASIC SKILL QUESTIONS 25

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
17	**1**	**W**
18	**1-7**	**X**
19	**1**	**W**
20	**Evaluated on JS 7**	
21	**Evaluated on JS 8**	
22	**Evaluated on AS 3**	

INSTRUCTOR'S GUIDE

SERVICING ENGINE COOLING SYSTEMS

3

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Mike Allen's commentary, "Wake Up, You Hoser," in *Popular Mechanics* magazine, June 1993, p. 89.

Writing

R Have the students write a short (one paragraph to one page) explanation of the proposed cause of hose failure and how a technician can check for this problem.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **List safety rules for working with automotive cooling systems.**

R Explain these safety rules to the students and emphasize the importance of following the rules at all times. Add any other safety rules which may be applicable to your particular shop area or program standards.

O Have the students write a short paragraph about the importance of following the safety rules that are applicable to this unit.

OBJECTIVE 2 **Label the components of an engine cooling system indicated on an illustration.**

R Explain how a cooling system operates.

R Explain the two types of liquid cooling systems: open and closed and how each operates, pointing out the differences and similarities between the two.

O Show the students an engine cooling system in a vehicle, pointing out to them each of the components.

O Have one or two students point out to the other members of the group the various components on the vehicle's engine cooling system, naming each one they have learned.

OBJECTIVE 3

Match the names of cooling system components to descriptions of their functions.

R Show transparency 1 of the engine cooling system components, and explain the functions of each component.

O Have the various cooling system components available on exhibit for students to see what they look like outside of a vehicle.

O Ask several students to point out one or two of the various components on the vehicle's engine cooling system and describe the functions of each.

OBJECTIVE 4

Label the parts of a radiator cap assembly indicated on an illustration.

R Explain the safety hazards and precautions to follow when removing a radiator cap.

R Show transparency 2, pointing out the location of each part of the radiator cap assembly.

O Show a radiator cap assembly from a vehicle, and point out the various parts.

O Have the students practice labeling the parts on a sheet you have copied from a revised copy of Transparency Master 2 that does not have the parts labeled for them.

O Review the parts with them, using transparency 2 as an illustration to allow them to check their sheet for accuracy.

OBJECTIVE 5

Match the names of the parts of a radiator cap assembly to descriptions of their functions.

R Explain the role of the radiator cap in making the cooling system function properly.

R Explain how pressure affects the boiling point of coolant.

R Show transparency 2 of the radiator cap assembly parts, and describe the function of each part.

O Ask several students to explain to the class the function of certain radiator cap parts which you name. Discuss with the class the students' responses, and positively reinforce the answers so the students will hear the correct information.

OBJECTIVE 6 **Perform cooling system pressure tests. (Job Sheet 1)**

R See the general instructions for all Job Sheets.

OBJECTIVE 7 **Check coolant; inspect and test a radiator, radiator cap, coolant recovery tank, and hoses. (Job Sheet 2)**

R See the general instructions for all Job Sheets.

OBJECTIVE 8 **Inspect, test, and replace a thermostat. (Job Sheet 3)**

R See the general instructions for all Job Sheets.

OBJECTIVE 9 **Name types of cooling system fans shown in illustrations.**

R See the activities under Objective 10.

OBJECTIVE 10 **Match the names of types of cooling system fans to descriptions of their operation.**

R Show transparencies 3 and 4 and explain the operation and characteristics of each fan type.

O Show the students the types of cooling system fans in vehicles, and point out to them the various parts which make them function.

O Ask several students to share with the class the descriptions of the various types of cooling system fans which you name. Discuss with the class the students' responses, and positively reinforce the answers so students will hear the correct information.

O Ask the students to label the types of fans on a sheet you have copied from a revised Transparency Master that does not have the types labeled for them.

O Review the types of fans with the students, using transparencies 3 and 4 as illustrations to allow them to check their sheet for accuracy.

OBJECTIVE 11

Inspect, test, and replace a fan and fan components. (Job Sheet 4)

R See the general instructions for all Job Sheets.

OBJECTIVE 12

Diagnose cooling system problems. (Assignment Sheet)

R Copy and distribute Handout 1,Troubleshooting the Cooling System, and Handout 2, Cooling System Diagnosis Chart, for the students to read and use in completing this Assignment Sheet.

R Review Handouts 1 and 2 with the students.

R See the general instructions for all Assignment Sheets.

O Describe diagnostic scenarios, and ask various students to explain how they would troubleshoot that problem and what actions they would take to correct the problem. Follow each student's response with positive reinforcement so the students will hear the correct answer.

O Bring vehicles with various engine cooling system faults into the shop, and have students diagnose them and describe how the problem should be corrected. Discuss the means of diagnosis and the correct way to fix the problem.

O Invite a technician to the classroom to show students how to troubleshoot various problems and/or describe to them problems that have been brought into his or her shop and how these problems were corrected.

O Ask students to visit with various technicians in the community to find out what kinds of engine cooling system problems they have encountered with vehicles.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.

- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.

- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.

- Complete the appropriate sections of the Competency Profiles.

- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The items marked with an asterisk are included in the Instructor's Resource Package.

Publications

- Allen, Mike. "Wake Up You Hoser." Popular Mechanics, June 1993, p. 89.
- *Troubleshooting the Cooling System*, Handout 1. *
- *Cooling System Diagnostic Chart*, Handout 2. *
- *Measuring and Learning Competency Gains: The Pretest/Posttest Approach*. Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 74074-4364, or call 800-522-5810, 1992.

UNIT REFERENCES

Publications

- Bono, Saverio G., and William J. deKryger. *Auto Technology: Theory and Service*, (2nd ed.). Albany, NY: Delmar Publishers, Inc., 1990.
- *Chevrolet Trucks C/K Pickup Service Manual, 1990*. Chevrolet Motor Co.
- *Chilton's Auto Repair Manual, 1985, Domestic and Canadian Cars from 1978 through 1985*. Chilton Way, Radnor, PA: Chilton Book Co., 1984.
- Crouse, William H. *Automotive Mechanics*, (8th ed.). New York: McGraw-Hill Book Co., Gregg Division, 1980.
- Crouse, William H. and Donald L. Anglin. *The Auto Book*, (3rd ed.). New York: McGraw-Hill Book Co., Gregg Division, 1984.

  —. *Automotive Engines*, (7th ed.). New York: McGraw-Hill Book Co., Gregg Division, 1986.

  —. *Automotive Fuel, Lubricating, and Cooling Systems*, (6th ed.). New York: McGraw-Hill Book Co., Gregg Division.

  —. *Automotive Mechanics*, (9th ed.). New York: McGraw-Hill Book Co., Gregg Division, 1985.

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- *Cutlass Ciera Service Manual*, 1988. General Motors Corp., 1988.
- deKryger, William J., Robert R. Kovacik and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, OH: South-Western Publishing Co., 1986.
- deKryger, William J. and Saverio G. Bono. *Auto Technology: Theory and Service, Service Manual*, (2nd ed.). Albany, NY: Delmar Publishers, Inc., 1990.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, IL: Goodheart-Willcox Co., Inc., 1990.
- *Engine Cooling System and Components*. Ford Parts and Service Division, Training and Publications Dept., 1987.
- *Engine Performance Diagnosis and Tune-Up*. Check-Chart Publications, a division of H. M. Gousha. Harper Collins Publishers, 1989.
- Erjavec, Jack and Robert Scharff. *Automotive Technology: A Systems Approach*. Albany, NY: Delmar Publishers, Inc., 1992.

—. *Automotive Technology: A Systems Approach, Tech Manual*. Albany, NY: Delmar Publishers, Inc., 1992.

- *GEO Metro Service Manual, 1989*. General Motors Corp., 1988.
- Hughes, James G. *Automotive Engine Tune-Up and Diagnosis*. Englewood Cliffs, NJ: Prentice Hall, 1988.
- Layne, Ken. *Automotive Engine Performance Tuneup, Testing, and Service Practice Manual*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1986.
- *Mitchell Auto Mechanics*, (2nd ed.). Mitchell International, Inc. Englewood Cliffs, NJ: Prentice Hall, 1991.
- *Motor Auto Repair Manual*, (49th ed.). New York: Hearst Books/Business Publishing Group, a division of the Hearst Corp., 1985.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals*. South Holland, IL: Goodheart-Willcox Co., Inc., 1985.

—. *Auto Service and Repair Manual.* South Holland, IL: Goodheart-Willcox Co., Inc., 1984.

- Toboldt, William K. and Larry Johnson. *Automotive Encyclopedia.* South Holland, IL: Goodheart-Willcox Co., Inc., 1983.
- Webster, Jay. *Auto Mechanics.* Encino, CA: Collier Macmillan Publishers, 1980.

ASSIGNMENT SHEET

OBJECTIVE 12

Assignment Sheet

1. N
2. N
3. Y
4. Y
5. Y
6. Y
7. Y
8. N
9. N
10. N

WRITTEN TEST

OBJECTIVE 1

Answers should include the following information in any order:

- Check the fan for cracked, bent, or damaged blades before running the engine with the hood open.
- Disconnect the power to an electric fan before working near it.
- Never remove the radiator cap from a closed coolant system except to flush or test the system.
- Never remove the radiator cap if the radiator is warm to the touch.
- Never perform cooling system service while the engine is hot or the coolant is under pressure.
- When removing a radiator cap from a radiator that is cool to the touch, cover the cap with a thick rag or wear gloves to protect your hands from any steam or hot coolant which may still be present.
- Clean up coolant immediately if it is spilled.
- Dispose of coolant properly according to the latest EPA standards.

- Do not swallow coolant, inhale its fumes, or allow it to touch your skin.
- Never reuse antifreeze containers for other purposes, especially for storage of consumable products.
- Do not spill coolant on hot engine systems.

OBJECTIVE 2

1. water pump
2. temperature sending unit
3. fan
4. radiator cap
5. coolant recovery tank
6. transmission oil cooler
7. radiator
8. radiator hoses
9. drains
10. water jacket
11. heater core
12. heater hose
13. thermostat

OBJECTIVE 3

1. D
2. E
3. F
4. L
5. O
6. B
7. H
8. I
9. J
10. M
11. C
12. N
13. K
14. G
15. A

OBJECTIVE 4

1. pressure relief valve spring
2. upper sealing gasket
3. vacuum vent valve
4. overflow tube
5. safety stop
6. cam locking surface
7. lower sealing gasket

OBJECTIVE 5

1. C
2. G
3. A
4. D
5. B
6. F
7. E

OBJECTIVE 6

Evaluated on Job Sheet 1.

OBJECTIVE 7	**Evaluated on Job Sheet 2.**
OBJECTIVE 8	**Evaluated on Job Sheet 3.**
OBJECTIVE 9	1. power flex fan 2. thermo-clutch fan 3. viscous-clutch fan 4. cross fan 5. electric fan
OBJECTIVE 10	1. D 2. A 3. B 4. C 5. E
OBJECTIVE 11	**Evaluated on Job Sheet 4.**
OBJECTIVE 12	**Evaluated on the Assignment Sheet.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 3 — SERVICING ENGINE COOLING SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 63

TOTAL NUMBER OF BASIC SKILL QUESTIONS 38

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1-11	W, E
2	1-13	X
3	1-15	S
4	1-7	X
5	1-7	S
6	Evaluated on JS 1	
7	Evaluated on JS 2	
8	Evaluated on JS 3	
9	1-5	X
10	1-5	S
11	Evaluated on JS 4	
12	Evaluated on AS	

SERVICING EXHAUST SYSTEMS

4

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read William F. Allman's article, "Good News About Noise," from *U.S. News & World Report*, September 9, 1991, pp. 59-60. Ask them to consider how manufacturers have made the exhaust system not only more efficient, but quieter as well.

Writing

R Have the students write a short (one paragraph to one page) explanation of how manufacturers could make the exhaust systems of vehicles more efficient and what they think the reaction would be from consumers.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of the procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1

Label the parts of an exhaust system indicated on an illustration.

R With the vehicle raised, point out the exhaust system components on an actual vehicle.

OBJECTIVE 2

Match the names of exhaust system components to descriptions of their functions.

R Explain the function of each component of the exhaust system.

OBJECTIVE 3

Perform a backpressure test on an exhaust system. (Job Sheet 1)

- R Explain to the students what exhaust problems may cause low backpressure.
- R See the general instructions for all Job Sheets.

OBJECTIVE 4

Inspect, service, and replace exhaust system components located in the engine compartment. (Job Sheet 2)

- R Explain the relationship between exhaust system components, pointing out that because the exhaust system is made up of several components, each must be in good condition for the whole system to perform correctly.
- R See the general instructions for all Job Sheets.

OBJECTIVE 5

Inspect, service, and replace exhaust system components located outside the engine compartment. (Job Sheet 3)

- R See the general instructions for all Job Sheets.
- O Assign specific students to explain to the class the design and function of each of the exhaust system components.

OBJECTIVE 6

Describe the operation of a catalytic converter.

- R Explain to the students how a catalytic converter operates.

OBJECTIVE 7

Name types of catalytic converters shown in illustrations.

- R Use transparency 2 to show the students the two different types of catalytic converters, and explain how the two types of catalytic converters differ.
- O Explain catalytic action in a chemical change.

OBJECTIVE 8

Match the names of versions of catalytic converters to descriptions or explanations of their operation.

- R Explain the operation of the five versions of catalytic converters.

OBJECTIVE 9

Inspect, test, service, and replace the catalytic converter of an exhaust system. (Job Sheet 4)

R Explain why the catalytic converter must be in good condition for the exhaust system to perform correctly.

R See the general instructions for all Job Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

Publications

- Allman, William F. "Good News About Noise." *U.S. News & World Report*, Sept. 9, 1991, pp. 59-60.

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach.* Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 1992. For ordering information call 800-522-5810.

UNIT REFERENCES

Publications

- Bono, Saverio G. and William J. deKryger. *Auto Technology: Theory & Service.* Albany, NY: Delmar Publishers, Inc., 1990.
- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics.* New York: Macmillian/McGraw-Hill, 1993.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, IL: Goodheart-Willcox Co., Inc., 1985.

ANSWERS — SERVICING EXHAUST SYSTEMS — 4

WRITTEN TEST

OBJECTIVE 1

1. exhaust manifold
2. crossover pipe
3. connecting pipe
4. connecting pipe
5. resonator
6. tail pipe
7. muffler
8. catalytic converter
9. exhaust pipe
10. EFE (early fuel evaporation system)
11. oxygen sensor

OBJECTIVE 2

1. G
2. A
3. J
4. E
5. H
6. B
7. I
8. D
9. C
10. F

OBJECTIVE 3

Evaluated on Job Sheet 1.

OBJECTIVE 4

Evaluated on Job Sheet 2.

OBJECTIVE 5

Evaluated on Job Sheet 3.

OBJECTIVE 6

A catalytic converter intercepts harmful pollutants in engine exhaust and changes them into harmless ones through the use of a catalyst. Inside the catalytic converter, a catalyst (commonly platinum, palladium, or rhodium) thinly coats a ceramic surface designed to expose the exhaust to as much catalyst as possible. As the exhaust flows through the catalytic converter, the catalyst causes the chemicals in the pollutants to change into harmless gases. The exhaust gases leaving the catalytic converter have a much lower concentration of pollutants than they did when they came in.

OBJECTIVE 7

1. pellet
2. honeycomb

OBJECTIVE 8

1. D
2. E
3. A
4. B
5. C

OBJECTIVE 9

Evaluated on Job Sheet 4.

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 4 — SERVICING EXHAUST SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 29

TOTAL NUMBER OF BASIC SKILL QUESTIONS 16

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1-11	X
2	1-10	S
3	Evaluated on JS 1	
4	Evaluated on JS 2	
5	Evaluated on JS 3	
6	1	W, S
7	1-2	X
8	1-5	S
9	Evaluated on JS 4	

INSTRUCTOR'S GUIDE

EVALUATING ENGINE CONDITION

5

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Ken Freund's article, "What's in a Tune-Up?" in the November 1992 *Trailer Life* magazine, pp. 58-67.

Writing

R Have the students write one or two paragraphs explaining the purpose of a tune-up.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **List the major steps that should be included in an engine tune-up.**

OBJECTIVE 2 **Compare and contrast valve train timing and ignition timing.**

R Explain how valve train timing and ignition timing differ and how they are similar.

OBJECTIVE 3 **Give reasons why proper valve train timing is important to correct engine operation.**

R Explain how improper valve train timing can affect emissions.

OBJECTIVE 4 **Name types of valve trains shown in illustrations.**

R Use transparencies 1 and 2 to help you explain the differences between the two types of valve trains.

R Show the students the location and the parts of an overhead valve train and an overhead cam valve train on actual vehicles.

OBJECTIVE 5 **Match the names of valve train parts to descriptions of their functions.**

R Use transparencies 1 and 2 to help you describe the functions of the parts of valve trains.

OBJECTIVE 6 **List three ways the camshaft part of a valve train is driven.**

R Explain the advantages and disadvantages of the three ways the camshaft can be driven.

OBJECTIVE 7 **Verify correct valve timing. (Job Sheet 1)**

R See the general instructions for all Job Sheets.

OBJECTIVE 8 **Adjust valves. (Job Sheet 2)**

R See the general instructions for all Job Sheets.

OBJECTIVE 9 **Perform cylinder compression tests. (Job Sheet 3)**

R Explain the use of Handout 1, Compression Diagnosis Chart.

R See the general instructions for all Job Sheets.

OBJECTIVE 10 **Perform a cylinder leakage test. (Job Sheet 4)**

R See the general instructions for all Job Sheets.

OBJECTIVE 11 **Interpret cylinder compression test results. (Assignment Sheet 1)**

R See the general instructions for all Assignment Sheets.

OBJECTIVE 12 **State reasons why a vehicle may require use of high octane fuel.**

R Explain high compression engines and why they may require high octane fuel.

O Explain octane ratings and how they differ.

OBJECTIVE 13 **List problems which may be created by using high octane fuel in a vehicle designed to use regular fuel.**

OBJECTIVE 14 **List problems which may be created by using regular fuel in a vehicle designed to use high octane fuel.**

OBJECTIVE 15 **List common engine performance problems.**

OBJECTIVE 16 **List common causes of engine mechanical problems.**

OBJECTIVE 17 **List common causes of engine lubrication problems.**

OBJECTIVE 18 **List common causes of engine overheating.**

OBJECTIVE 19 **List engine parts that are most frequently affected by normal engine wear and tear.**

R Show the students an older engine with normal wear and tear and point out the parts most frequently affected by normal engine wear and tear.

OBJECTIVE 20 **List the steps of engine inspection.**

OBJECTIVE 21 **Inspect an engine assembly for leaks. (Job Sheet 5)**

R See the general instructions for all Job Sheets.

OBJECTIVE 22 **Match colors of exhaust to the condition or problem indicated by the color.**

OBJECTIVE 23 **Describe an abnormal exhaust odor and the problem it indicates.**

OBJECTIVE 24 **Diagnose the cause of unusual exhaust color, odor, and sound. (Assignment Sheet 2)**

R See the general instructions for all Assignment Sheets.

OBJECTIVE 25 **Perform engine vacuum tests. (Job Sheet 6)**

R See the general instructions for all Job Sheets.

OBJECTIVE 26 **Interpret vacuum gauge readings. (Assignment Sheet 3)**

R See the general instructions for all Assignment Sheets.

OBJECTIVE 27 **Perform a cylinder power balance test. (Job Sheet 7)**

R See the general instructions for all Job Sheets.

OBJECTIVE 28 **Calibrate an exhaust gas analyzer, test a vehicle's exhaust, and obtain exhaust gas readings. (Job Sheet 8)**

R See the general instructions for all Job Sheets.

OBJECTIVE 29 **Match the names of engine diagnostic tests to the engine conditions they evaluate.**

OBJECTIVE 30 **Name types of engine test equipment shown in illustrations.**

OBJECTIVE 31 **Match the names of engine test equipment to the information which can be obtained with that equipment.**

R Have the students look at transparencies 3, 4, 5, 6 and 7 as you explain the information that can be obtained with the equipment.

R Display examples of the various types of test equipment for the students to examine.

OBJECTIVE 32 **List the steps in making a diagnostic road test.**

OBJECTIVE 33 **Verify driver's complaint. (Assignment Sheet 4)**

R See the general instructions for all Assignment Sheets.

OBJECTIVE 34 **Diagnose the cause of unusual engine noise and vibration problems. (Assignment Sheet 5)**

R See the general instructions for all Assignment Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.
- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.
- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.
- Describe the rating scale used on the skills test.
- Reteach and retest as necessary.
- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The items marked with an asterisk are included in the Instructor's Resource Package.

Publications

- *Compression Diagnosis Chart.* Handout 1.*
- *Engine Noise Diagnosis Chart.* Handout 3.*
- Freund, Ken. "What's in a Tune-Up?" *Trailer Life*, November 1992, pp. 58-67.
- *Interpreting Engine Vacuum Readings.* Handout 2.*

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach.* Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 74074-4364, or call 800-522-5810, 1992.

UNIT REFERENCES

Publications

- Anglin, Donald L. and William H. Crouse. *Motor Vehicle Inspection.* New York: McGraw-Hill, Gregg Division, 1978.
- Bono, Saverio and William J. de Kryger. *Automotive Technology: Theory and Service*, (2nd ed.). Albany, NY: Delmar Publishers, 1990.

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  —. *Automotive Engine Tune-Up and Diagnosis*. Englewood Cliffs, NJ: Prentice Hall, 1988.

- Stockel, Martin W. and Martin T. Stockel. *Auto Service and Repair*. South Holland, IL: Goodheart-Willcox Co., Inc., 1984.

- Toboldt, William K. et. al. *Automotive Encyclopedia*, (rev. ed.). South Holland, IL: Goodheart-Willcox Co., Inc, 1989.

ASSIGNMENT SHEETS

OBJECTIVE 11

Assignment Sheet 1

1.	B	6.	A
2.	C	7.	B
3.	A	8.	B
4.	D		
5.	C		

OBJECTIVE 24

Assignment Sheet 2

1.	D	6.	C
2.	B	7.	A
3.	D	8.	C
4.	D		
5.	A		

OBJECTIVE 26

Assignment Sheet 3

1.	B	6.	A
2.	B	7.	D
3.	D	8.	C
4.	A		
5.	B		

OBJECTIVE 33

Assignment Sheet 4

1.	D	6.	C
2.	C	7.	D
3.	D	8.	B
4.	B	9.	C
5.	D		

OBJECTIVE 34

Assignment Sheet 5

1. C
2. A
3. B
4. B
5. B

WRITTEN TEST

OBJECTIVE 1

Answers should include the following information in any order:

- Replace the spark plugs.
- Service the distributor, including points and condenser replacement or electronic distributor maintenance.
- Check and adjust the ignition timing.
- Replace the air and fuel filters.
- Adjust the fuel system.
- Test the emission control system and service.
- Perform a general inspection.
- Take the vehicle for a road test.

OBJECTIVE 2

	Valve Train Timing	**Ignition Timing**
1. Electronically controlled	X	X
2. Valve opens in relation to piston position	X	
3. Mechanically controlled	X	X
4. Critical to effective emission control	X	X
5. Spark plugs fire in relation to the position of the engine pistons.		X
6. Faulty timing may cause the engine to run rough.	X	X

OBJECTIVE 3	Answers should include the following information in any order: • to increase engine power • to increase fuel economy • to decrease pollutants
OBJECTIVE 4	1. overhead cam 2. overhead valve
OBJECTIVE 5	1. A 6. D 2. G 7. E 3. F 4. C 5. B
OBJECTIVE 6	Answers should include the following information in any order: • belt • chain • gear set
OBJECTIVE 7	**Evaluated on Job Sheet 1.**
OBJECTIVE 8	**Evaluated on Job Sheet 2.**
OBJECTIVE 9	**Evaluated on Job Sheet 3.**
OBJECTIVE 10	**Evaluated on Job Sheet 4.**
OBJECTIVE 11	**Evaluated on Assignment Sheet 1.**
OBJECTIVE 12	Answers should include the following information in any order: • The vehicle has a high compression engine. • The vehicle uses a turbocharger or supercharger.

OBJECTIVE 13

Answers should include the following information in any order:

- engine running problems
- surging
- missing

OBJECTIVE 14

Answers should include the following information in any order:

- knocks or pings
- detonation
- preignition
- engine noise
- engine hesitation
- engine surge
- loss of power
- poor fuel economy

OBJECTIVE 15

Answers should include the following information in any order:

- engine misses
- engine surge
- loss of power
- poor mileage

OBJECTIVE 16

Answers should include the following information in any order:

- lack of lubrication
- overheating
- abuse
- lack of maintenance

OBJECTIVE 17

Answers should include the following information in any order:

- low oil level
- restricted oil galleries
- clogged oil filter or pickup screen
- improper oil viscosity

OBJECTIVE 18

Answers should include the following information in any order:

- low coolant level
- defective water pump
- worn or broken water pump belts
- defective thermostat
- restriction in the cooling system
- incorrect ignition timing

OBJECTIVE 19

Answers should include the following information in any order:

- pistons and rings
- crankshaft and bearings
- camshaft and valve train parts

OBJECTIVE 20

Answers should include the following information in any order:

- Inspect the vehicle for signs of poor maintenance and abuse.
- Check the oil dipstick for acceptable level of oil and condition of oil.
- Check beneath the vehicle for leaking fluids.
- Check for unusual smells.
- Examine all belts and hoses for wear and tear.
- Check for weak hoses and loose connections.

OBJECTIVE 21

Evaluated on Job Sheet 5.

OBJECTIVE 22

1. B
2. A
3. C
4. D
5. A

OBJECTIVE 23

1. rotten egg odor
2. too little oxygen in the air-fuel mixture

OBJECTIVE 24

Evaluated on Assignment Sheet 2.

OBJECTIVE 25 **Evaluated on Job Sheet 6.**

OBJECTIVE 26 **Evaluated on Assignment Sheet 3.**

OBJECTIVE 27 **Evaluated on Job Sheet 7.**

OBJECTIVE 28 **Evaluated on Job Sheet 8.**

OBJECTIVE 29

1. A
2. D
3. E
4. B
5. C

OBJECTIVE 30

1. cylinder leakage tester
2. exhaust gas analyzer
3. vacuum gauge
4. tach-dwell meter
5. pressure gauge

OBJECTIVE 31

1. C
2. E
3. B
4. D
5. A

OBJECTIVE 32

1. Listen.
2. Ask Questions.
3. Observe.
4. Consult the service manual troubleshooting guide and all technical service bulletins.
5. Make the road test.
6. Note the results.
7. Make a preliminary diagnosis.
8. Check your diagnosis.

OBJECTIVE 33 **Evaluated on Assignment Sheet 4.**

OBJECTIVE 34 **Evaluated on Assignment Sheet 5.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 5 — EVALUATING ENGINE CONDITION

TOTAL NUMBER OF TEST QUESTIONS 99

TOTAL NUMBER OF BASIC SKILL QUESTIONS 60

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1-8	T
2	1-6	X
3	1-3	X
4	1-2	X
5	1-7	X
6	1-3	S
7	Evaluated on JS 1	
8	Evaluated on JS 2	
9	Evaluated on JS 3	
10	Evaluated on JS 4	
11	Evaluated on AS 1	
12	1-2	S
13	1-3	S, T
14	1-8	S
15	1-4	X
16	1-4	X
17	1-4	X
18	1-6	X

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 5 — EVALUATING ENGINE CONDITION

TOTAL NUMBER OF TEST QUESTIONS 99

TOTAL NUMBER OF BASIC SKILL QUESTIONS 60

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
19	1-3	X
20	1-6	T
21	Evaluated on JS 5	
22	1-5	S, T
23	1-2	S, T
24	Evaluated on AS 2	
25	Evaluated on JS 6	
26	Evaluated on AS 3	
27	Evaluated on JS 7	
28	Evaluated on JS 8	
29	1-5	S, T
30	1-5	S
31	1-5	S, T
32	1-8	T
33	Evaluated on AS 4	
34	Evaluated on AS 5	

INSTRUCTOR'S GUIDE

UNDERSTANDING ENGINE COMPUTER CONTROLS

6

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Paul Weissler's article, "Inside the '91s," from *Popular Mechanics* magazine, October 1990, pp. 32-35. Ask them to consider what technological advances manufacturers have made in computerizing various automotive systems and how those advances have improved the vehicles.

Writing

R Have the students write a short (one paragraph to one page) explanation of how manufacturers have improved engine performance through the use of computers and what they think the reaction is from consumers to these changes.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1

Describe the functions of the three main components of engine computer control systems.

R Show the students examples of a sensor, an engine computer, and a control device as you explain how these components work together.

R Show the students examples of sensors, control devices, and an engine computer on an actual vehicle.

R Have the students read the Handout to help them understand engine computer control systems.

O Show the students examples of automotive computers other than the engine computer.

OBJECTIVE 2

Match the names of common sensors to the function monitored by the sensor.

R Display examples of different types of sensors in the classroom.

O Write the names of common sensors on one set of cards. Write their descriptions on another set of cards. Ask the students to match the names of the sensors to their correct descriptions.

OBJECTIVE 3

Match the names of common sensors to illustrations of the sensors.

OBJECTIVE 4

Match the names of common control devices to the functions they control.

R Display examples of different types of control devices in the classroom.

O Write the names of common control devices on one set of cards. Write their descriptions on another set of cards. Ask the students to match the names of the control devices to their correct descriptions.

OBJECTIVE 5

Match the names of common control devices to illustrations of the devices.

OBJECTIVE 6

List information that can be monitored by an engine computer analyzer.

OBJECTIVE 7

Name types of engine computer analyzers shown in illustrations.

R Show the students an actual engine computer analyzer and a scan tool.

OBJECTIVE 8

Compare and contrast engine computer analyzers and scan tools.

R Use transparencies 10 and 11 and the material in the Information Sheet to help you compare types of engine computer analyzers.

OBJECTIVE 9

Hook up an engine computer analyzer and a scan tool. (Job Sheet)

R Explain what types of engine problems can be diagnosed with a scan tool and an engine computer analyzer.

R Use an actual engine computer analyzers to demonstrate how improper hook-up can lead to inaccurate or no results on tests that are performed.

R See the general instructions for all Job Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.
- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.
- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.
- Reteach and retest as necessary.
- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The item marked with an asterisk is included in the Instructor's Resource Package.

Publications

- *Automotive Computer Functions*. Handout. *
- Weissler, Paul. "Inside the '91s," *Popular Mechanics*, October 1990, pp. 32-35.

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach*. Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 1992. For ordering information call 800-522-5810.

UNIT REFERENCES

Publications

- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics*. New York: Macmillian/McGraw-Hill, 1993.
- Duffy, James E. *Auto Engines*. South Holland, IL: The Goodheart-Willcox Co., Inc., 1988.

  —. Duffy, James E. *Modern Automotive Mechanics*. South Holland, IL: The Goodheart-Willcox Co., Inc., 1985.
- Erjavec, Jack and Robert Scharff. *Automotive Technology, A Systems Approach*. Albany, NY: Delmar Publishers, Inc., 1992.

ANSWERS

UNDERSTANDING ENGINE COMPUTER CONTROLS

6

WRITTEN TEST

OBJECTIVE 1

1. provide information to the engine computer
2. analyzes the information, decides what changes to make, if any, and signals the control devices
3. carry out the actions as directed by the engine computer to control engine systems

OBJECTIVE 2

1.	J	7.	B	13.	L
2.	A	8.	I		
3.	E	9.	C		
4.	G	10.	D		
5.	K	11.	H		
6.	M	12.	F		

OBJECTIVE 3

1. manifold absolute pressure (MAP) sensor
2. air charge sensor (ACS)
3. coolant temperature sensor (CTS)
4. knock sensor
5. throttle position sensor (TPS)
6. crankshaft position sensor
7. oxygen (O_2) sensor
8 barometric pressure sensor (BAP)
9. exhaust gas recirculation (EGR) sensor (EVP)
10. vehicle speed sensor (VSS)
11. mass air flow (MAF) sensor
12. camshaft position sensor

OBJECTIVE 4

1.	D
2.	B
3.	A
4.	F
5.	C
6.	E

OBJECTIVE 5

1. engine cooling fan
2. idle air control valve
3. exhaust gas recirculation valve
4. carbon canister purge valve
5. fuel injector

OBJECTIVE 6

Answers should include the following information in any order:

- operating condition of the engine systems
- ignition system operation
- engine temperature
- engine speed
- makeup of the engine exhaust
- electrical information
- engine vacuum available to engine vacuum-operated devices
- fuel pressure

OBJECTIVE 7

1. scan tool
2. engine computer analyzer

OBJECTIVE 8

1. A. battery-powered
   B. AC-powered

2. A. full screen of information
   B. full screen of information

3. A. usually monitors engine computer information only
   B: yes

4. A. with new software
   B. with new software

5. A. usually requires a separate printer to provide a paper printout
   B. yes

6. A. $400 to $1,000
   B. $8,000 +

7. A. yes
   B. only if the unit is portable

8. A. hand-held
   B. mounted in a roll-around cabinet or can be portable

9. A. yes
   B. yes

10. A. usually single hook-up
    B. multiple hook-ups

11. A. able to draw conclusions from data monitored
    B. able to draw conclusions from data monitored

OBJECTIVE 9 **Evaluated on the Job Sheet.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 6 — UNDERSTANDING ENGINE COMPUTER CONTROL

TOTAL NUMBER OF TEST QUESTIONS 71

TOTAL NUMBER OF BASIC SKILL QUESTIONS 35

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1-3	S
2	1-13	X
3	1-12	X
4	1-6	X
5	1-5	X
6	1-8	T
7	1-2	S
8	1-11 (A & B)	S, T
9	Evaluated on JS	

INSTRUCTOR'S GUIDE

SERVICING IGNITION SYSTEMS

7

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Don Chaiken's article, "Distributorless Ignition – How It Works," in *Popular Mechanics* magazine, June 1992, p. 90. Tell them to pay special attention to how this ignition system operates without a distributor, and why this is an improvement over ignition systems that use a distributor.

Writing

R Have the students write a short (one page) step-by-step outline of how a distributorless ignition system works, specifically including the way it operates without a distributor. Also include the reason why distributorless ignition systems are considered an improvement over ignition systems that use a distributor.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **State the purpose of an automotive ignition system.**

OBJECTIVE 2 **Identify three types of ignition systems shown in illustrations.**

OBJECTIVE 3 **Label ignition system components indicated on illustrations of the three types.**

R Use transparencies 1, 2, and 3 to illustrate each classification while you explain to the students how the components on each operate together.

R Show the students the components of each type on actual vehicles.

OBJECTIVE 4 **Match the names of ignition system components to descriptions of their functions.**

R Describe the function of each part while allowing the students to handle the parts of actual ignition systems.

OBJECTIVE 5 **Describe the operation of an electronic distributor ignition system.**

OBJECTIVE 6 **Describe the operation of an electronic distributorless ignition system.**

OBJECTIVE 7 **Compare and contrast types of ignition systems.**

R Explain the similarities and differences between the different types of ignition systems.

OBJECTIVE 8 **State the purpose of a triggering system.**

OBJECTIVE 9 **Match the names of types of triggering systems for electronic ignition systems to descriptions of their operation.**

R Allow the students to examine types of triggering systems as you identify them and explain their operation.

OBJECTIVE 10 **State the purpose of an ignition coil.**

OBJECTIVE 11 **State the main difference between the primary circuit and the secondary circuit.**

OBJECTIVE 12 **Distinguish between primary and secondary circuit components on an illustration.**

OBJECTIVE 13 **Match the names of the parts of an ignition coil to an illustration.**

R Use transparency 5 to illustrate the parts of an ignition coil while you explain its operation.

R Allow the students to examine parts of an actual ignition coil as you pass one around.

OBJECTIVE 14

Match the names of the parts of a distributor to an illustration.

R Use transparency 6 to illustrate the parts of a distributor while you explain its operation.

OBJECTIVE 15

Label the parts of a spark plug indicated on an illustration.

R Use transparency 7 to illustrate the parts of a spark plug as you explain its operation.

OBJECTIVE 16

Match the names of types of spark plugs to statements describing their qualities.

R Allow the students to examine types of actual spark plugs.

OBJECTIVE 17

Match the names of secondary pattern oscilloscope tests to the ignition system condition or function monitored by the test.

R Explain the importance of each test to the students.

OBJECTIVE 18

Identify abnormal oscilloscope patterns shown in illustrations.

OBJECTIVE 19

Draw a typical primary oscilloscope pattern for an electronic distributor ignition.

R Use transparency 12 or Handout 1 to illustrate an electronic distributor primary ignition pattern so the students can draw it on their paper. Check each student's drawing to make sure it is correct.

OBJECTIVE 20

Draw a typical primary oscilloscope pattern for a contact point ignition.

R Use transparency 13 or Handout 1 to illustrate a contact point ignition pattern so the students can draw it on their paper. Check each student's drawing to make sure it is correct.

OBJECTIVE 21

Circle the area of an oscilloscope pattern which corresponds to ignition coil ON.

R Display transparency 14 to illustrate the area corresponding to oscilloscope ignition coil ON. Allow the students to circle it on their paper. Check each student's drawing to make sure the area is correctly circled.

OBJECTIVE 22

Circle the area of an oscilloscope pattern which corresponds to ignition coil OFF.

R Display transparency 14 to illustrate the area corresponding to oscilloscope ignition coil OFF. Allow the students to circle it on their paper. Check each student's drawing to make sure the area is correctly circled.

R Explain the term *dwell* and its use in ignition diagnosis.

OBJECTIVE 23

Inspect, test, repair, and replace the ignition primary circuit wiring and components. (Job Sheet 1)

R See the general instructions for all Job Sheets.

OBJECTIVE 24

Inspect, test, adjust, service, repair, and replace the ignition points and condenser. (Job Sheet 2)

R See the general instructions for all Job Sheets.

OBJECTIVE 25

Inspect, test, service, repair, and replace the ignition system secondary circuit wiring and components. (Job Sheet 3)

R Have the students use Handout 2 and examples of defective spark plugs to help them learn to diagnose spark plug conditions and their causes.

R See the general instructions for all Job Sheets.

OBJECTIVE 26

Inspect, test, and replace ignition coils. (Job Sheet 4)

R See the general instructions for all Job Sheets.

OBJECTIVE 27

Inspect, test, and replace an electronic ignition wiring harness and connectors. (Job Sheet 5)

R See the general instructions for all Job Sheets.

OBJECTIVE 28

Inspect, test, and replace electronic ignition system pick-up sensors or triggering devices. (Job Sheet 6)

R See the general instructions for all Job Sheets.

OBJECTIVE 29

State the purpose of a spark timing system.

OBJECTIVE 30

Match the names of types of spark timing systems to descriptions of their operation.

OBJECTIVE 31

Match the names of types of ignition systems to the names of the spark timing systems used with them.

OBJECTIVE 32

Test and adjust spark timing systems. (Job Sheet 7)

R See the general instructions for all Job Sheets.

OBJECTIVE 33

Inspect, test, repair, and replace the components of a spark timing system. (Job Sheet 8)

R See the general instructions for all Job Sheets.

OBJECTIVE 34

Inspect, test, repair, and replace electrical/electronic components and circuits of a spark timing system. (Job Sheet 9)

R See the general instructions for all Job Sheets.

OBJECTIVE 35

Inspect, test, and service a distributor. (Job Sheet 10)

R See the general instructions for all Job Sheets.

OBJECTIVE 36

Inspect, test, and replace an electronic ignition system control unit. (Job Sheet 11)

R See the general instructions for all Job Sheets.

OBJECTIVE 37

Diagnose no-starting, engine misfire, poor driveability, spark knock, power loss, and poor mileage problems. (Assignment Sheet)

R See the general instructions for all Assignment Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.

- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The items marked with an asterisk are included in the Instructor's Resource Package.

Publications

- Chaiken, Don. "Distributorless Ignition." *Popular Mechanics*, June 1992, p. 90.
- *No-Starting, Hard Starting, and Engine Misfire Diagnosis Chart.* Handout 3.*
- *Oscilloscope Patterns Diagnosis Chart.* Handout 4.*
- *Spark Plug Conditions.* Handout 2.*
- *Typical Primary Oscilloscope Patterns.* Handout 1.*

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach.* Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 1992. For ordering information call 800-522-5810.

UNIT REFERENCES

Publications

- Carley, Larry. *Do-It-Yourself Auto Repair.* Skokie, IL: Publications International, 1986.

- Chaikin, Don. "Distributorless Ignition." *Popular Mechanics,* June 1992, p. 90.

- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics,* (10th ed.). Westerville, OH: Glencoe Division, McGraw-Hill School Publishing Co., 1993.

- *Distributorless Ignition Systems.* Detroit, MI: Ford Motor Co. Technical Training Parts and Services Division, 1989.

- *Electronic Distributorless Ignition Systems.* Detroit, MI: Ford Motor Co. Technical Training Parts and Service Division, 1990.

- *GM Distributorless Ignition Systems.* Warren, MI: General Motors Corp. Service Technology Group, 1989.

- Duffy, James E. *Auto Engines.* South Holland, IL: Goodheart-Willcox Co., Inc., 1988.

- Layne, Ken. *Automotive Engine Performance Practice Manual.* Englewood Cliffs, NJ: Prentice-Hall Publishing Co., 1986.

- *Popular Mechanics Guide to Basic Auto Repair and Maintenance.* New York: Book Division, The Hearst Corp., 1976 , pp. 229-231.

- *Understanding Automotive Oscilloscope Patterns.* Crystal Lake, IL: Sun Technical Services, Sun Electric Corp., 1982.

- Weissler, Paul. "Troubleshooting Your Electronic Ignition." *Popular Mechanics,* August 1993, pp. 73-76.

ANSWERS

SERVICING IGNITION SYSTEMS

7

ASSIGNMENT SHEET

OBJECTIVE 37

Assignment Sheet

1. B
2. C
3. D
4. B
5. D
6. B
7. B
8. D
9. B
10. D
11. C
12. C
13. C
14. A
15. A

WRITTEN TEST

OBJECTIVE 1

The purpose of an automotive ignition system is to ignite the air-fuel mixture in the engine cylinders.

OBJECTIVE 2

A. electronic distributorless ignition system
B. electronic distributor ignition system
C. contact point type ignition system

OBJECTIVE 3

A.
  1. spark plugs
  2. engine computer
  3. to engine sensors — crankshaft position sensor, camshaft position sensor, knock sensor
  4. ignition control module (with ignition coils)
  5. ignition switch
  6. battery

B.
  1. spark plugs
  2. distributor cap
  3. vacuum advance
  4. distributor
  5. ignition control module
  6. ignition coil
  7. ignition switch
  8. battery

C. 1. spark plugs
2. distributor cap
3. vacuum advance
4. distributor
5. ignition coil
6. ignition resistor
7. ignition switch
8. battery

OBJECTIVE 4

1. L
2. M
3. C
4. B
5. F
6. A
7. D
8. G
9. H
10. E
11. J
12. I
13. K

OBJECTIVE 5

When the ignition switch is turned ON, transistors electronically cause the distributor to ground the ignition coil and begin the flow of high voltage electricity from the ignition coil through the distributor cap and rotor to the spark plug, igniting the air-fuel mixture in each cylinder. Electronic devices cause the distributor to continue to ground the coil at split second intervals, timing the sparks with valve operation.

OBJECTIVE 6

When the ignition switch is turned ON, crank and/or cam sensors signal the position of the crankshaft to the engine computer to ground the ignition coil and begin the flow of voltage to the spark plug at each cylinder, creating a spark which ignites the air-fuel mixture in the cylinder and electronically times the sparks with valve operation.

OBJECTIVE 7

Similarities and Differences Between Ignition Systems

	Contact Point	**Electronic Distributorless**	**Electronic Distributor**
Number of coils	Single coil	Multi-coil	Single coil
Regulation of spark timing	Controlled by contact points	Controlled by computer	Controlled by computer
Maintenance	Regular maintenance of contact points	None required	None required
Firing order of cylinders	Determined by distributor	Determined by computer	Determined by distributor
Purpose	Ignite air-fuel mixture in the cylinders	Ignite air-fuel mixture in the cylinders	Ignite air-fuel mixture in the cylinders

OBJECTIVE 8

The triggering system turns the flow of current to the ignition coil on and off.

OBJECTIVE 9

1. C
2. A
3. B

OBJECTIVE 10

The ignition coil increases the voltage of the vehicle's battery until it is great enough to ignite the air-fuel mixture in the engine cylinders.

OBJECTIVE 11

The electric current in the primary circuit is low voltage, and the current in the secondary circuit is high voltage.

OBJECTIVE 12

1. P
2. P
3. P
4. P
5. S
6. S
7. S
8. S
9. S

OBJECTIVE 13

1. H
2. D
3. F
4. A
5. E
6. I
7. G
8. B
9. C

OBJECTIVE 14

1. C
2. B
3. A
4. E
5. D

OBJECTIVE 15

1. terminal
2. gasket or seal
3. insulator tip
4. side electrode
5. air gap
6. center electrode
7. shell
8. insulator ribs

OBJECTIVE 16

1. C
2. D
3. A
4. F
5. G
6. E
7. B

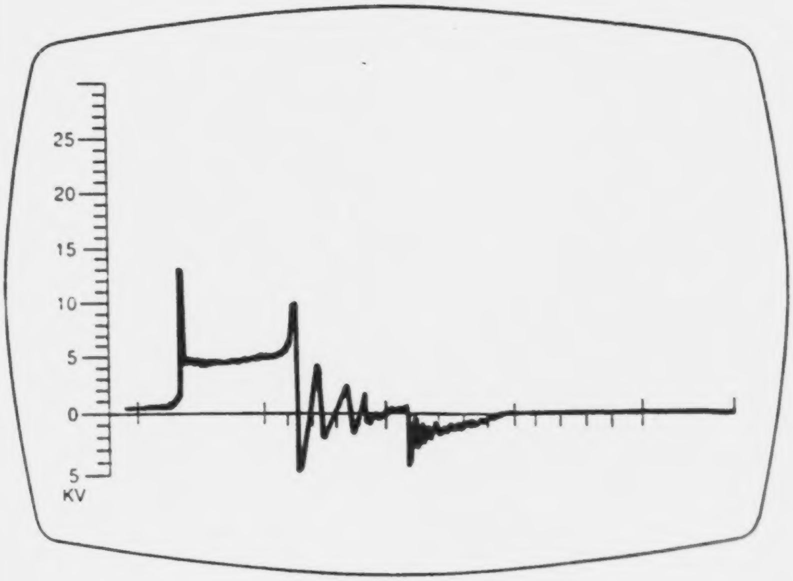
OBJECTIVE 17

1. B
2. A
3. C

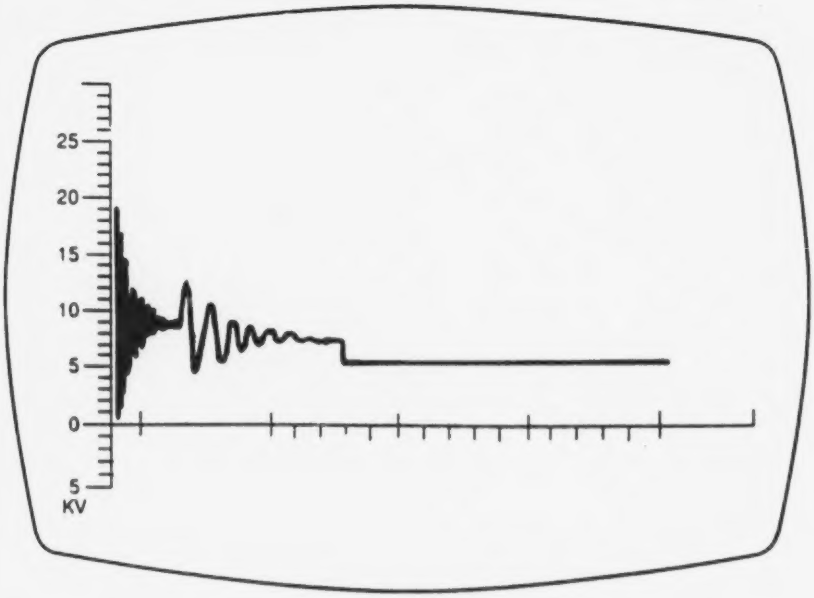
OBJECTIVE 18

1. oscillations lost
2. low spark line
3. high spark line
4. firing line drops

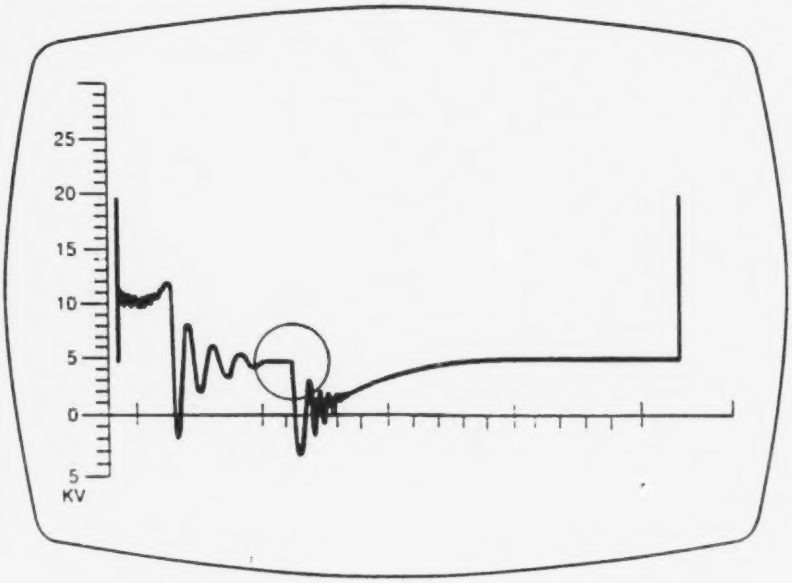
OBJECTIVE 19



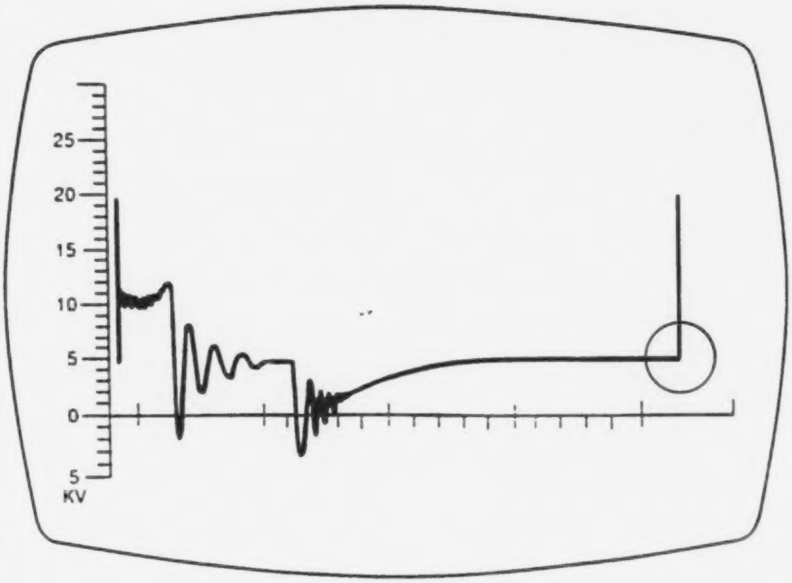
OBJECTIVE 20



OBJECTIVE 21



OBJECTIVE 22



OBJECTIVE 23 **Evaluated on Job Sheet 1.**

OBJECTIVE 24 **Evaluated on Job Sheet 2.**

OBJECTIVE 25 **Evaluated on Job Sheet 3.**

OBJECTIVE 26 **Evaluated on Job Sheet 4.**

OBJECTIVE 27 **Evaluated on Job Sheet 5.**

OBJECTIVE 28 **Evaluated on Job Sheet 6.**

OBJECTIVE 29 A spark timing control system adjusts the timing of the spark's ignition of the air-fuel mixture in the cylinder.

OBJECTIVE 30	1. C 2. A 3. B
OBJECTIVE 31	1. A 2. B,C 3. A,B,C
OBJECTIVE 32	**Evaluated on Job Sheet 7.**
OBJECTIVE 33	**Evaluated on Job Sheet 8.**
OBJECTIVE 34	**Evaluated on Job Sheet 9.**
OBJECTIVE 35	**Evaluated on Job Sheet 10.**
OBJECTIVE 36	**Evaluated on Job Sheet 11.**
OBJECTIVE 37	**Evaluated on the Assignment Sheet.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 7 — SERVICING IGNITION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 120

TOTAL NUMBER OF BASIC SKILL QUESTIONS 56

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1	W
2	1-3	X
3	1-22	X
4	1-13	S
5	1	W
6	1	W
7	1-5 (A, B, & C)	S
8	1	W
9	1-3	S
10	1	W
11	1	W
12	1-9	X
13	1-9	X
14	1-7	X
15	1-8	X
16	1-7	S
17	1-3	S, T

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 7 — SERVICING IGNITION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 120

TOTAL NUMBER OF BASIC SKILL QUESTIONS 56

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
18	1-4	S, T
19	1	S, T
20	1	S, T
21	1	S, T
22	1	S, T
23	Evaluated on JS 1	
24	Evaluated on JS 2	
25	Evaluated on JS 3	
26	Evaluated on JS 4	
27	Evaluated on JS 5	
28	Evaluated on JS 6	
29	1	W
30	1-3	X
31	1-3	X
32	Evaluated on JS 7	
33	Evaluated on JS 8	
34	Evaluated on JS 9	

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 7 — SERVICING IGNITION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 120

TOTAL NUMBER OF BASIC SKILL QUESTIONS 56

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
35	Evaluated on JS 10	
36	Evaluated on JS 11	
37	Evaluated on AS	

SERVICING FUEL DELIVERY SYSTEMS

8

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Stuart F. Brown's article, "The Theme Is Green - Hydrogen Engines," in *Popular Science* magazine, February 1992, pp. 50-55. Ask them to consider what technological advances have been made in producing engines that use hydrogen fuel systems and how those advances could reduce air pollution.

Writing

R Have the students write a short (one paragraph to one page) explanation of some of the advantages and disadvantages of hydrogen as a future fuel for vehicles.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Review and explain all general guidelines, safety cautions, and warnings.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Make sure that all tools, equipment, and supplies are available.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **List the two main classifications of fuel delivery systems.**

OBJECTIVE 2 **Compare and contrast the two main classifications of fuel delivery systems.**

OBJECTIVE 3 **Name three types of fuel delivery systems shown in illustrations.**

R Show the students examples of the three types of systems on actual vehicles.

OBJECTIVE 4 **Describe the operation of the three types of fuel delivery systems.**

R Use transparencies 1, 2, and 3 to help you explain how the three types of systems operate.

OBJECTIVE 5

Label fuel delivery system parts indicated on illustrations.

OBJECTIVE 6

Match the names of fuel delivery system parts to descriptions of their functions.

O Make two sets of cards, one set with the names of fuel delivery system parts and the other set with descriptions of their functions. Let the students take turns matching the cards.

OBJECTIVE 7

Inspect, clean, and replace fuel delivery system components. (Job Sheet 1)

R See the general instructions for all Job Sheets.

OBJECTIVE 8

Name three types of fuel pumps shown in illustrations.

R Use transparencies 4, 5, and 6 to help you explain the differences between the three types of fuel pumps.

R Have examples of fuel pumps in the classroom for students to hold and examine.

OBJECTIVE 9

State the amount of fuel pressure present during the operation of different types of fuel systems.

R Explain what alterations must be made in fuel system components to enable them to handle the higher pressures used by fuel injected engines.

OBJECTIVE 10

Name types of fuel filters from examples shown in your classroom.

R Create a display in the classroom with an example of each type of fuel filter. Use filters that can be taken apart, even if they are not designed to be.

OBJECTIVE 11

Compare and contrast fuel filters used in carbureted type fuel delivery systems and fuel filters used in injector type fuel delivery systems.

OBJECTIVE 12

Match the names of types of fuel system diagnostic tests to statements describing the tests' purposes.

OBJECTIVE 13

Inspect, test, and replace fuel pumps, pump control systems, and fuel filters. (Job Sheet 2)

- R Use actual vehicles to show the students different places where fuel pumps are installed.
- R See the general instructions for all Job Sheets.

OBJECTIVE 14

Inspect, service, repair, and replace air filtration system components. (Job Sheet 3)

- R Create a display of various types of air filters for the students to examine.
- R Show the students the location of air cleaners on various different vehicles.
- R See the general instructions for all Job Sheets.

OBJECTIVE 15

List common fuel contaminants.

- R Display samples of clean and contaminated fuel and describe the causes of such contamination.

OBJECTIVE 16

Remove and replace the fuel tank and fuel gauge sending unit. (Job Sheet 4)

- R Show students an example of a fuel gauge sending unit and describe how it may become damaged or nonfunctional.
- R See the general instructions for all Job Sheets.

OBJECTIVE 17

Inspect and replace fuel system components and check fuel condition. (Job Sheet 5)

- R See the general instructions for all Job Sheets.
- O Prepare jars with different mixtures of gasoline and contaminants and have the students diagnose what contaminants are in each jar.

OBJECTIVE 18

Test an oxygen sensor. (Job Sheet 6)

- R Explain to the students what problems can occur because of a malfunctioning oxygen sensor.

R Prepare a display of oxygen sensors whose tips are light grey, white, tan, and black.

R See the general instructions for all Job Sheets.

OBJECTIVE 19

Remove and replace an oxygen sensor. (Job Sheet 7)

R See the general instructions for all Job Sheets.

OBJECTIVE 20

Diagnose fuel delivery system problems. (Assignment Sheet)

R See the general instructions for all Assignment Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.
- Reteach and retest as necessary.
- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The items marked with an asterisk are included in the Instructor's Resource Package.

Publications

- Brown, Stuart F. "The Theme is Green - Hydrogen Engines." *Popular Science*, February 1992, pp. 50-55.
- *Carbureted Fuel Delivery System Diagnosis Chart.* Handout 1.*
- *Fuel Injected Delivery System Diagnosis Chart.* Handout 2.*

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/ Posttest Approach.* Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 74074-4364, or call 800-522-5810, 1992.

UNIT REFERENCES

Publications

- Bono, Saverio G. and William J. deKryger. *Auto Technology: Theory and Service.* Albany, NY: Delmar Publishers, Inc., 1990.
- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics*, (9th ed.). New York: McGraw Hill, 1985.

  — *Fuel, Lubricating and Cooling Systems*, (6th ed.). New York: Gregg Division, McGraw-Hill, 1981.
- Duffy, James E. *Auto Engines.* South Holland, IL: Goodheart-Willcox Co., Inc., 1988.

  — *Modern Automotive Mechanics.* South Holland, IL: Goodheart-Willcox Co., Inc., 1985.
- Duffy, James E. and Howard Smith. *Auto Fuel Systems.* South Holland, IL: Goodheart-Willcox Co., Inc., 1987.
- *Engine Repair Specialist.* Stillwater, OK: Oklahoma Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1993.
- Erjavec, Jack and Robert Scharff. *Auto Technology: A Systems Approach.* Albany, NY: Delmar Publishers, Inc., 1990.
- *1981 to 1985 Carbureted Driveability and Emissions Diagnostics.* General Motors Corp., Rochester, NY.
- *1987 Carbureted Driveability and Emissions Diagnostics.* General Motors Corp., Rochester, NY.
- *1987 Port Fuel Injection Driveability and Emissions Diagnostics.* General Motors Corp. Rochester, NY.
- Hughes, James G. *Automotive Engines.* New York: Harcourt Brace Jovanovich, 1990.

- Scharff, Robert and the Editors of MOTOR SERVICE. *Complete Fuel Systems and Emission Controls*. Albany, NY, Delmar Publishers, Inc., 1989.

ASSIGNMENT SHEET

OBJECTIVE 21

Assignment Sheet

Answers on bulleted items may be in any order.

1. a. No problem, the sensor is normal .
   b. Reinstall the sensor.

2. - dirty air filter
   - dirty carburetor

3. - no fuel in the carburetor
   - carburetor flooded
   - fuel pump pressure too high

4. Check for a dirty fuel filter.

5. - defective fuel pump or fuel pump relay
   - wrong PCV valve
   - leaking manifold gasket
   - defective injectors

6. a. defective carburetor
   b. dirty fuel filter

7. - low fuel pressure
   - restriction in air intake
   - defective oxygen sensor

8. fuel pump

9. - fuel restriction
   - fuel contamination
   - vacuum leaks

10. - dirty fuel filter
    - dirty carburetor jets

WRITTEN TEST

OBJECTIVE 1

Answers should include the following information in any order:

- carbureted
- fuel injected

OBJECTIVE 2

		Fuel Injected	Carbureted
1.	Uses pressure to mix air and fuel	X	
2.	Uses vacuum to mix air and fuel		X
3.	Delivers fuel to the engine	X	X
4.	Responds quickly to changing conditions	X	
5.	Produces fewer exhaust emissions	X	
6.	Older technology		X
7.	Newer technology	X	
8.	More precise metering of fuel	X	
9.	More efficient and cost effective	X	

OBJECTIVE 3

See answers for "A" in objective 5 below.

OBJECTIVE 4

See answers for "B" in objective 5 below.

OBJECTIVE 5

See answers for "C" below.

I. A. throttle body fuel injection

B. One or two injectors mix fuel into the air in the intake manifold which then delivers the mixture to each cylinder.

C. 1. throttle body
2. engine computer
3. fuel filter
4. in-tank fuel filter
5. throttle body
6. throttle valves

II. A. port fuel injection

B. An injector for each cylinder injects the fuel into the intake port where it is mixed with air.

C. 1. engine computer
2. in-tank fuel pump
3. fuel filter
4. chassis-mounted fuel pump
5. injectors

6. fuel rail
7. fuel pressure regulator
8. throttle body

III. A. carbureted

B. Air and fuel is mixed in the carburetor and the intake manifold delivers the mixture to the intake valve of each cylinder.

C. 1. vapor return line
2. fuel tank
3 fuel line
4. fuel pump
5. charcoal canister
6. fuel line
7. in-line fuel filter
8. carburetor

OBJECTIVE 6

1. I
2. M
3. C
4. G
5. A
6. K
7. E
8. L
9. D
10. F
11. H
12. J
13. B

OBJECTIVE 7

Evaluated on Job Sheet 1.

OBJECTIVE 8

1. external electric fuel pump
2. tank-mounted electric fuel pump
3. mechanical fuel pump

OBJECTIVE 9

1. 9-15
2. 30-40
3. 5

OBJECTIVE 10

The order of the answers will vary depending on the instructor's display, but will include all of the following:

- carburetor-mounted canister-type filter
- carburetor-mounted paper filter
- fuel pump-mounted filter
- in-line canister-type filter

OBJECTIVE 11

1. C
2. F
3. C, F
4. C
5. F
6. C
7. F
8. C
9. F

OBJECTIVE 12

1. B
2. A
3. C

OBJECTIVE 13

Evaluated on Job Sheet 2.

OBJECTIVE 14

Evaluated on Job Sheet 3.

OBJECTIVE 15

Answers should include the following information in any order:

- water
- rust
- dirt
- excess alcohol

OBJECTIVE 16

Evaluated on Job Sheet 4.

OBJECTIVE 17

Evaluated on Job Sheet 5.

OBJECTIVE 18

Evaluated on Job Sheet 6.

OBJECTIVE 19

Evaluated on Job Sheet 7.

OBJECTIVE 20

Evaluated on the Assignment Sheet.

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 8 — SERVICING FUEL DELIVERY SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 87

TOTAL NUMBER OF BASIC SKILL QUESTIONS 40

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1-2	X
2	1-9 (A&B)	S
3	1-3	X
4	1-3	S
5	1-22	X
6	1-13	S
7	Evaluated on JS 1	
8	1-3	X
9	1-3	S
10	1-4	X
11	1-9	X
12	1-3	S, T
13	Evaluated on JS 2	
14	Evaluated on JS 3	
15	1-4	X
16	Evaluated on JS 4	
17	Evaluated on JS 5	
18	Evaluated on JS 6	

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 8 — SERVICING FUEL DELIVERY SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 87

TOTAL NUMBER OF BASIC SKILL QUESTIONS 40

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
19	**Evaluated on JS 7**	
20	**Evaluated on AS**	

INSTRUCTOR'S GUIDE

SERVICING FUEL INJECTION SYSTEMS

9

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Don Chaikin's article, "How It Works, Fuel Injection," in *Popular Mechanics* magazine, August 1991, p. 68.

Writing

R Have the students write one or two paragraphs explaining how the fuel is delivered to a fuel injection system.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **Name the two types of fuel injection systems shown in illustrations.**

R Show the students transparencies 1 and 2 as you explain the operation of the two types of fuel injection systems.

OBJECTIVE 2 **State the method of fuel induction for each type of fuel injection system.**

OBJECTIVE 3 **State the number and placement of injectors in each type of fuel injection system.**

OBJECTIVE 4

Match the names of the two ways fuel injection systems are controlled with descriptions of their control.

OBJECTIVE 5

Match the names of methods of sequencing injectors with descriptions of the sequence.

OBJECTIVE 6

Label the parts of a fuel injector indicated on an illustration.

R Use transparency 3 to help you explain how a fuel injector works.

R Allow the students to handle examples of actual fuel injectors.

OBJECTIVE 7

Match the names of engine monitoring and control devices which assist in fuel injection system operation with descriptions of the conditions they monitor or control.

OBJECTIVE 8

Match the names of the operating conditions of a fuel injector to descriptions of the injector's operation during each condition.

OBJECTIVE 9

State the function of an idle speed control system.

O Explain how the engine load can change during idling.

OBJECTIVE 10

Describe the operation of an idle speed control system.

OBJECTIVE 11

State the function of a cold start enrichment system.

OBJECTIVE 12

Arrange the steps of cold start enrichment system operation in order.

OBJECTIVE 13

State the function of an acceleration enrichment system.

OBJECTIVE 14

Describe the operation of an acceleration enrichment system.

OBJECTIVE 15

State the function of a fuel pressure regulation system.

O Pass a fuel pressure regulator around the classroom while explaining its operation.

OBJECTIVE 16

Describe the operation of a fuel pressure regulation system.

OBJECTIVE 17

Describe the operation of a deceleration control system.

OBJECTIVE 18

Check and adjust the fuel injection idle speed and fuel mixture on a closed-loop fuel control system. (Job Sheet 1)

R Allow the students to look at a scan tool or engine computer analyzer as you review its operation.

R Explain the operation of a closed-loop and an open-loop fuel control system.

R See the general instructions for all Job Sheets.

OBJECTIVE 19

Inspect, test, adjust, and replace components of an idle speed control system. (Job Sheet 2)

R Allow the students to look at the components of an idle speed control system on an actual vehicle.

R See the general instructions for all Job Sheets.

OBJECTIVE 20

Remove, clean, inspect, test, repair, and replace vacuum and electrical components and connections of a fuel injection system. (Job Sheet 3)

R Explain why vacuum leaks are a common and critical source of problems with the fuel injection system.

R See the general instructions for all Job Sheets.

OBJECTIVE 21

Inspect, test, repair, and replace components of a fuel pressure regulation system. (Job Sheet 4)

R See the general instructions for all Job Sheets.

OBJECTIVE 22 **Verify engine operating temperature. (Job Sheet 5)**

R Review the ohmmeter function of a digital multimeter.

R See the general instructions for all Job Sheets.

OBJECTIVE 23 **Inspect, test, adjust, repair, and replace a fuel injection cold start enrichment system. (Job Sheet 6)**

R See the general instructions for all Job Sheets.

O Explain Handout 2, Acceptable and Unacceptable Injector Spray Patterns.

OBJECTIVE 24 **Inspect, test, adjust, and replace an acceleration enrichment system and components. (Job Sheet 7)**

R See the general instructions for all Job Sheets.

OBJECTIVE 25 **Test the operation of a deceleration control system. (Job Sheet 8)**

R See the general instructions for all Job Sheets.

OBJECTIVE 26 **Inspect, test, and replace a deceleration fuel reduction or shut off system and components. (Job Sheet 9)**

R See the general instructions for all Job Sheets.

OBJECTIVE 27 **Name the two fuel injector tests which test for clogged fuel injectors.**

OBJECTIVE 28 **Describe the test procedures for these two fuel injector tests.**

O Explain Handout 2, Acceptable and Unacceptable Injector Spray Patterns.

OBJECTIVE 29 **Perform fuel injector tests. (Job Sheet 10)**

R See the general instructions for all Job Sheets.

OBJECTIVE 30 **Inspect, clean, and replace fuel injectors, and clean a fuel injection system. (Job Sheet 11)**

R See the general instructions for all Job Sheets.

OBJECTIVE 31

Diagnose fuel injection performance problems. (Assignment Sheet)

R See the general instructions for all Assignment Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The items marked with an asterisk are included in the Instructor's Resource Package.

Publications

- *Acceptable and Unacceptable Injector Spray Patterns.* Handout 2.*
- Chaikin, Don, "How It Works, Fuel Injection," *Popular Mechanics*, August 1991, p. 68.
- *Comparison of Throttle Body and Port Fuel Injection Systems.* Handout 1.*
- *Preliminary Checklist for Fuel Injection Diagnosis.* Handout 3.*
- *Port Fuel Injection System Diagnosis Chart.* Handout 5.*
- *Throttle Body Fuel Injection System Diagnosis Chart.* Handout 4.*

UNIT REFERENCES

Publications

- Anglin, Donald L. and William H. Crouse. *Motor Vehicle Inspection*. New York: McGraw- Hill, Greg Division, 1978.

- Bono, Saverio and William J. de Kryger. *Automotive Technology: Theory and Service*. (2nd ed.). Albany, NY: Delmar Publishers Inc.,1990.

- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics*, (9th ed.). New York: McGraw-Hill Publishing Co., 1985.

- de Kryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, OH: South-Western Publishing Co., 1980.

- Duffy, James. *Auto Engines*. South Holland, IL: Goodheart-Willcox Co. Inc., 1988.

  —. *Modern Automotive Mechanics*. South Holland, IL: Goodheart-Willcox Co. Inc., 1988.

- General Motors Service Technology Group. *Fuel Injection*. General Motors Corp., 1991.

- Gilles, Tim. *Automotive Engines: Diagnosis, Repair, and Rebuilding*. (2nd ed.). Albany, NY: Delmar Publishers Inc., 1991.

- Scharff, Robert and the Editors of *Motor Service. Complete Fuel Systems and Emission Control*. Albany, NY: Delmar Publishers Inc., 1989.

- Stockel, Martin W. and Martin T. Stockel. *Auto Service and Repair*. South Holland, IL: Goodheart-Willcox Co. Inc., 1984.

- Toboldt, William K., et. al. *Automotive Encyclopedia*. (rev. ed.). South Holland, IL: Goodheart-Willcox Co. Inc., 1989.

ASSIGNMENT SHEET

OBJECTIVE 32

Assignment Sheet

1. B
2. A
3. A
4. B
5. D
6. A
7. D
8. C
9. A
10. D

WRITTEN TEST

OBJECTIVE 1

1. port fuel injection system

2. throttle body fuel injection system

OBJECTIVE 2

1. Fuel is sprayed into the intake ports of each cylinder.

2. Fuel is sprayed into the engine intake manifold.

OBJECTIVE 3

1. An injector in the intake port of each cylinder sprays fuel into the intake port.

2. One or two injectors are mounted on the throttle body assembly and spray fuel into the top center of the intake manifold.

OBJECTIVE 4

1. B
2. A

OBJECTIVE 5

1. C
2. B
3. A

OBJECTIVE 6

1. inlet fuel filter
2. coil
3. return spring
4. nozzle
5. needle valve
6. electrical connector
7. o-ring

OBJECTIVE 7

1. E
2. D
3. A
4. C
5. B

OBJECTIVE 8

1. A
2. B
3. C
4. C
5. A

OBJECTIVE 9

An idle speed control system prevents changing engine load from stalling the engine.

OBJECTIVE 10

Engine sensors detect changing load during idle and send this information to the engine computer. The engine computer directs the idle air control motor to move the idle air control valve, allowing air to pass around the throttle valve. The airflow sensor detects the additional air flow and makes the adjustment to increase idle speed, preventing stalling.

OBJECTIVE 11

A cold start enrichment system aids cold engine starting by supplying extra fuel to enrich the air-fuel mixture.

OBJECTIVE 12

4, 2, 3, 6, 5, 1

OBJECTIVE 13

An acceleration enrichment system increases engine power needed for acceleration by enriching the air-fuel mixture.

OBJECTIVE 14

The throttle position sensor and the manifold absolute pressure sensor signal the engine computer that acceleration should begin. The engine computer increases the pulse width of the injectors, the air-fuel mixture is enriched, and the engine power for acceleration is increased.

OBJECTIVE 15	A fuel pressure regulation system maintains a uniform amount of pressure at the fuel injector to assure its proper operation.
OBJECTIVE 16	The fuel pressure regulator is constructed to respond to manifold vacuum pressure to allow the appropriate amount of pressure at the injector.
OBJECTIVE 17	The throttle position sensor and the manifold absolute pressure sensor signal the engine computer that deceleration should begin. The engine computer decreases the pulse width of the injectors, the air-fuel mixture is leaned, and the engine power is reduced, causing deceleration.
OBJECTIVE 18	**Evaluated on Job Sheet 1.**
OBJECTIVE 19	**Evaluated on Job Sheet 2.**
OBJECTIVE 20	**Evaluated on Job Sheet 3.**
OBJECTIVE 21	**Evaluated on Job Sheet 4.**
OBJECTIVE 22	**Evaluated on Job Sheet 5.**
OBJECTIVE 23	**Evaluated on Job Sheet 6.**
OBJECTIVE 24	**Evaluated on Job Sheet 7.**
OBJECTIVE 25	**Evaluated on Job Sheet 8.**
OBJECTIVE 26	**Evaluated on Job Sheet 9.**

OBJECTIVES 27 & 28

The answers for "A" are those for objective 28 and can be in any order.

The answers for "B" are those for objective 29 and must be paired with the correct answers for "A" as shown below.

A. injector spray pattern test
B. A visual inspection is made of the pattern made by the gasoline spray coming out of the nozzle of the injector during operation. An abnormal spray pattern indicates the injector is clogged.

A. injector drop test
B. A fuel pressure gauge is used to measure the fuel pressure as each injector is sprayed individually. Any drop in pressure indicates that the injector is clogged.

OBJECTIVE 29 **Evaluated on Job Sheet 10.**

OBJECTIVE 30 **Evaluated on Job Sheet 11.**

OBJECTIVE 31 **Evaluated on the Assignment Sheet.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 9 — SERVICING FUEL INJECTION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 46

TOTAL NUMBER OF BASIC SKILL QUESTIONS 22

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1-2	X
2	1-2	X
3	1-2	X
4	1-2	S
5	1-3	S
6	1-7	X
7	1-5	S
8	1-5	X
9	1	W
10	1	W
11	1	W
12	1-6	X
13	1	W
14	1	W, S
15	1	W
16	1	W, S
17	1	W, S
18	Evaluated on JS 1	

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 9 — SERVICING FUEL INJECTION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 46

TOTAL NUMBER OF BASIC SKILL QUESTIONS 22

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
19	Evaluated on JS 2	
20	Evaluated on JS 3	
21	Evaluated on JS 4	
22	Evaluated on JS 5	
23	Evaluated on JS 6	
24	Evaluated on JS 7	
25	Evaluated on JS 8	
26	Evaluated on JS 9	
27	1-2	T
28	1-2	T
29	Evaluated on JS 10	
30	Evaluated on JS 11	
31	Evaluated on AS	

INSTRUCTOR'S GUIDE

SERVICING TURBOCHARGER SYSTEMS

10

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have students read Mac DeMere's article, "Toyota Supra Turbo," in *Motor Trend* magazine, March 1993, pp. 54-57.

Writing

R Have the students write a short (one paragraph to one page) comparison of turbocharged/supercharged vehicles to non-turbocharged/supercharged vehicles of the same class. Include any examples of vehicles equipped with twin turbos and the effect on engine response time.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1

State the function of a turbocharger/supercharger.

R Explain the function of a turbocharger/supercharger to the students.

O Invite a technician, service manager, or other automotive expert from your area to speak to the students about turbochargers and superchargers. Encourage the students to ask questions of the speaker.

OBJECTIVE 2

Label the parts of a turbocharger indicated on an illustration.

R Show the students actual parts of a turbocharger.

OBJECTIVE 3

Match the names of the parts of a turbocharger to descriptions of their functions.

- R Have the students look at transparency 1 as you describe the function of each part of a turbocharger.
- O Have students write a short description of the way a turbocharger operates. Tell them to include each part and its function.

OBJECTIVE 4

List the reasons why lubrication is important for a turbocharger.

- R Explain to the students the reasons why lubrication is important in a turbocharger.
- R Show the students parts of a turbocharger damaged by lack of proper lubrication.

OBJECTIVE 5

Test the operation of a turbocharger system. (Job Sheet 1)

- R Explain to students the things they should look and listen for when testing the operation of a turbocharger.
- R See the general instructions for all Job Sheets.

OBJECTIVE 6

Remove, clean, inspect, repair, and replace turbocharger system components. (Job Sheet 2)

- R See the general instructions for all Job Sheets.

OBJECTIVE 7

Identify the causes of turbocharger failure. (Assignment Sheet 1)

- R See the general instructions for all Assignment Sheets.
- O Divide the students into groups. Give them a specified time and have them discuss the questions and decide on the correct answers for Assignment Sheet 1 together.
- O Discuss the questions and the reasons for the answers chosen together as a class.

OBJECTIVE 8

Label the parts of a supercharger indicated on an illustration.

R Allow the students to examine the actual parts of a supercharger.

OBJECTIVE 9

Match the names of the parts of a supercharger to descriptions of their functions.

R Have the students look at transparency 2 as you describe the function of a supercharger.

O Have the students write a short description of the way a supercharger operates. Have them include each part and its function.

OBJECTIVE 10

Compare and contrast a turbocharger and a supercharger.

R Explain the similarities and differences between a turbocharger and a supercharger.

OBJECTIVE 11

Test the operation of a supercharger system. (Job Sheet 3)

R Explain to the students the things they should look and listen for when testing the operation of a supercharger.

R See the general instructions for all Job Sheets.

OBJECTIVE 12

Remove, clean, inspect, repair, and replace supercharger system components. (Job Sheet 4)

R See the general instructions for all Job Sheets.

OBJECTIVE 13

Identify the causes of supercharger failure. (Assignment Sheet 2)

R See the general instructions for all Assignment Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest*

Approach for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.

- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.

- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The items marked with an asterisk are included in the Instructor's Resource Package.

Publications

- DeMere, Mac. "Toyota Supra Turbo." *Motor Trend*, Vol. 45, No. 3, March 1993, pp. 54-57.
- *Supercharger Diagnosis Chart*. Handout 2.*
- *Turbocharger Diagnosis Chart*. Handout 1.*

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/ Posttest Approach*. Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 74074-4364, or call 800-522-5810, 1992.

UNIT REFERENCES

Publications

- Crouse, William. and Donald L. Anglin. *Automotive Mechanics*. Westerville, OH: Glencoe Publishing Co., 1993.
- DeMere, Mac. "Toyota Supra Turbo." *Motor Trend*, Vol. 45, No. 3, March 1993., pp. 54-57.
- Duffy, James E. *Auto Engines*. South Holland, IL: Goodheart-Willcox Publishing Co., Inc., 1988.

  —. *Modern Automotive Mechanics*. South Holland, IL: Goodheart-Willcox Publishing Co., Inc., 1990.
- Erjavec, Jack and Robert Scharff. *Automotive Technology*. New York: Delmar Publishers, Inc., 1992.

- Ford Motor Co. *1989 Domestic Cars Service & Repair.* San Diego: Mitchell International, Inc. 1989.

- General Motors. *Pontiac Bonneville Service Manual.* 1993.

  —. *Pontiac Sunbird Service Manual.* 1990.

- John Deere Service Publications. *Fundamentals of Service - Engines.* Moline, IL: Deere and Co., 1991.

ANSWERS

SERVICING TURBOCHARGER SYSTEMS

10

ASSIGNMENT SHEETS

OBJECTIVE 7

Assignment Sheet 1

1.	C	6.	C
2.	C	7.	A
3.	C	8.	B
4.	A	9.	B
5.	D		

OBJECTIVE 13

Assignment Sheet 2

1.	A	6.	C
2.	B	7.	A
3.	A	8.	B
4.	B	9.	D
5.	C	10.	A

WRITTEN TEST

OBJECTIVE 1

A turbocharger or supercharger increases engine power by forcing more air-fuel mixture into the engine's cylinders prior to combustion.

OBJECTIVE 2

1. actuator
2. compressor
3. wastegate
4. turbine housing
5. turbine
6. compressor housing

OBJECTIVE 3

1. C
2. A
3. E
4. B
5. D
6. F

OBJECTIVE 4

Answers should include the following information in any order:

- reduces friction at high rotational speeds
- cools parts
- reduces expansion of different metal parts

OBJECTIVE 5

Evaluated on Job Sheet 1.

OBJECTIVE 6

Evaluated on Job Sheet 2.

OBJECTIVE 7

Evaluated on Assignment Sheet 1.

OBJECTIVE 8

1. intercooler inlet tube
2. intercooler
3. air outlet adapter
4. drive belt pulley
5. supercharger
6. intake manifold
7. throttle body
8. supercharger inlet plenum
9. air bypass actuator
10. intercooler to intake manifold adapter
11. knock sensor
12. intercooler outlet tube

OBJECTIVE 9

1. L
2. D
3. E
4. I
5. J
6. A
7. F
8. B
9. C
10. G
11. H
12. K

OBJECTIVE 10

	Turbocharger	Supercharger
Function	Compresses air to boost engine power	Compresses air to boost engine power
Performance	35%-60% increase Lag between acceleration & turbo boost	35%-60% increase Instant response to acceleration
Operation	Exhaust-driven	Belt-driven
Lubrication System	Linked to engine	Self-contained
Normal Unit Noise	Pressure pulsation & gear noise	High frequency whine

OBJECTIVE 11 **Evaluated on Job Sheet 3.**

OBJECTIVE 12 **Evaluated on Job Sheet 4.**

OBJECTIVE 13 **Evaluated on Assignment Sheet 2.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 10 — SERVICING TURBOCHARGER SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 50

TOTAL NUMBER OF BASIC SKILL QUESTIONS 23

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1	W
2	1-6	X
3	1-6	X
4	1-3	X
5	Evaluated on JS 1	
6	Evaluated on JS 2	
7	Evaluated on AS 1	
8	1-12	X
9	1-12	S
10	1-5 (A & B)	S
11	Evaluated on JS 3	
12	Evaluated on JS 4	
13	Evaluated on AS 2	

INSTRUCTOR'S GUIDE

SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

11

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Paul Stenquist's article, "When Your Car Uses Too Much Oil," in *Popular Mechanics* magazine, December 1990, p. 99.

Writing

R Have the students write a short (one paragraph to one page) explanation of how the positive crankcase ventilation system can be tested to verify that it is working correctly.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **State the purpose of a positive crankcase ventilation system.**

OBJECTIVE 2 **Describe the operation of a positive crankcase ventilation system.**

R Use Figure 1 to help you explain how a positive crankcase ventilation system operates.

OBJECTIVE 3 **List the locations on a vehicle where a positive crankcase ventilation system may be installed.**

R Show the students the location of PCV systems on different vehicles.

OBJECTIVE 4

Test the operation of a positive crankcase ventilation system. (Job Sheet 1)

R See the general instructions for all Job Sheets.

OBJECTIVE 5

Inspect, service, and replace positive crankcase ventilation system parts. (Job Sheet 2)

R See the general instructions for all Job Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.
- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.
- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.
- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.
- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The item marked with an asterisk is included in the Instructor's Resource Package.

Publications

- Stenquist, Paul. "When Your Car Uses Too Much Oil." *Popular Mechanics*, December 1990, p. 99.
- *Positive Crankcase Ventilation System Diagnostic Chart.* Handout.*

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach.* Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 1992. For ordering information call 800-522-5810.

UNIT REFERENCES

Publications

- Bono, Saverio G. and William J. deKryger. *Auto Technology: Theory & Service*. Albany, NY: Delmar Publishers, Inc., 1990.
- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics*. New York: Macmillian/McGraw-Hill, 1993.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, IL: Goodheart-Willcox Co., Inc., 1975.
- *Engine Repair Specialist*. Stillwater, OK: Oklahoma Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1993.

ANSWERS

SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

11

WRITTEN TEST

OBJECTIVE 1

The positive crankcase ventilation (PCV) system reduces vehicle emissions and protects engine parts from sludge by removing blow-by from the crankcase.

OBJECTIVE 2

The positive crankcase ventilation (PCV) system works by allowing fresh air to be supplied to the crankcase where it is mixed with blow-by gases, directed through a PCV valve or vapor separator, and sent into the intake manifold. From the intake manifold, the gases go to the combustion chamber where they are burned.

OBJECTIVE 3

Answers should include the following information in any order:

- located between the valve cover and the intake manifold
- located between the engine block and the intake manifold

OBJECTIVE 4

Evaluated on Job Sheet 1.

OBJECTIVE 5

Evaluated on Job Sheet 2.

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 11 — SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 4

TOTAL NUMBER OF BASIC SKILL QUESTIONS 2

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	**1**	**W**
2	**1**	**W, S**
3	**1-2**	**X**
4	**Evaluated on JS 1**	
5	**Evaluated on JS 2**	

INSTRUCTOR'S GUIDE

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

12

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read the article, "EGR and Exhaust Simulation Developments," in *Automotive Engineering*, August 1993, pp. 14-15.

Writing

R Have the students write one or two paragraphs on the new Combustion Control by Vortex Stratification (CCVS) developed in 1992, explaining how it works and how it benefits our environment.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **State the function of an exhaust gas recirculation (EGR) system.**

R Explain the role vehicle emissions play in air pollution.

OBJECTIVE 2 **Describe the operation of an exhaust gas recirculation system.**

OBJECTIVE 3 **Identify whether an exhaust gas recirculation system is on or off during specified engine operating conditions.**

R Explain how vehicle driveability can be affected by EGR operation during specific engine operating conditions. Be sure to cover the exceptions contained in the note to this objective.

OBJECTIVE 4

Match the names of types of exhaust gas recirculation systems to descriptions of their operation.

R Display or pass different types of EGR valves around the classroom.

R Tell the students the many different names vehicle manufacturers have for EGR valves and EGR systems.

OBJECTIVE 5

Test the operation of an exhaust gas recirculation system. (Job Sheet 1)

R Review the operation of computer analyzers and scan tools.

R Review the Handout, Exhaust Gas Recirculation System Diagnosis Chart.

R See the general instructions for all Job Sheets.

OBJECTIVE 6

Inspect, test, repair, and replace electrical/electronic controls and wiring. (Job Sheet 2)

R Show the students EGR wiring and electrical/electronic controls in several makes and models of vehicles.

R See the general instructions for all Job Sheets.

OBJECTIVE 7

Inspect, test, repair, and replace vacuum/pressure controls, filters, and hoses. (Job Sheet 3)

R Show the students where the EGR vacuum/pressure controls, filters, and hoses are located in several makes and models of vehicles.

R See the general instructions for all Job Sheets.

OBJECTIVE 8

Inspect, test, repair, and replace the valve and exhaust passages. (Job Sheet 4)

R See the general instructions for all Job Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.

- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The item marked with an asterisk is included in the Instructor's Resource Package.

Publications

- "EGR and Exhaust Simulation Developments," *Automotive Engineering*, August 1993, pp. 14-15.
- *Exhaust Gas Recirculation System Diagnosis Chart*. Handout.*

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach*. Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 74074-4364, or call 800-522-5810, 1992.

UNIT REFERENCES

Publications

- Crouse, William J. and Donald L. Anglin. *The Auto Book*, (3rd ed.). New York: Gregg Division, McGraw-Hill, 1984.

  —. *Automotive Mechanics*, (9th ed.). New York: McGraw-Hill, 1985.

  —. *Workbook for Automotive Mechanics*, (9th ed.). New York: McGraw-Hill, 1985.

- de Kryger, William J., Robert T. Kovacik, and Saverio G Bono. *Auto Mechanics: Theory and Service.* Cincinnati, OH: South-Western Publishing Co., 1980.
- Duffy, James E. *Modern Automotive Mechanics,* (lst ed.). South Holland, IL: Goodheart-Willcox Publishing Co., Inc., 1990.
- Erjavec, Jack and Robert Scharff. *Automotive Technology: A Systems Approach.* Albany, NY: Delmar Publishers Inc., 1992.
- Fennema, Roger, Richard DuPuy, and Christine Boldt. *Engine Performance Diagnosis and Tune-up,* (2nd ed.). Chek-Chart Publications, a Division of H.M. Gousha, Harper Collins Publishers, 1989.

  —. *Engine Performance Diagnosis and Tune-up, Shop Manual,* (2nd ed.). Chek-Chart Publications, A Division of H. M. Gousha, Harper Collins Publishers, 1989.
- Hughes, James. *Automotive Engine Tune-up and Diagnosis.* Englewood Cliffs, NJ: Prentice Hall, 1988.
- Layne, Ken. *Automotive Engine Performance: Tuneup, Testing and Service, Practice Manual.* Englewood Cliffs, NJ: Prentice Hall, 1986.
- Scharff, Robert. *Complete Fuel Systems and Emission Control.* Albany, NY: Delmar Auto Services, Delmar Publishers, 1989.
- Stockel, Martin W. and Martin T. Stockel. *Auto Service and Repair.* South Holland, IL: Goodheart-Willcox Co., Inc., 1984.

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

WRITTEN TEST

OBJECTIVE 1	The exhaust gas recirculation (EGR) system reduces the amount of nitrogen oxide (NO_x) a vehicle emits into the air.
OBJECTIVE 2	An EGR system allows a small amount of exhaust gas to return through the intake manifold into the cylinders where, by reducing the combustion temperature, it lowers the amount of NO_x formed.
OBJECTIVE 3	1. off 2. off 3. on 4. on 5. off
OBJECTIVE 4	1. A 2. C 3. D 4. B 5. E
OBJECTIVE 5	**Evaluated on Job Sheet 1.**
OBJECTIVE 6	**Evaluated on Job Sheet 2.**
OBJECTIVE 7	**Evaluated on Job Sheet 3.**
OBJECTIVE 8	**Evaluated on Job Sheet 4.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 12 — SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 11

TOTAL NUMBER OF BASIC SKILL QUESTIONS 6

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	**1**	**W**
2	**1**	**W, S**
3	**1-5**	**X**
4	**1-4**	**S**
5	**Evaluated on JS 1**	
6	**Evaluated on JS 2**	
7	**Evaluated on JS 3**	
8	**Evaluated on JS 4**	

INSTRUCTOR'S GUIDE

SERVICING AIR INJECTION SYSTEMS

13

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read David Simanaitis's article in "Tech Tidbits," in *Road and Track* magazine, July 1993, pp. 132-133.

Writing

R Have the students write a one page evaluation of the test based on the author's opinion and other information they might have regarding this test.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate this procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **State the function of an air injection system.**

OBJECTIVE 2 **Label the components of a pump type air injection system indicated on an illustration.**

OBJECTIVE 3 **Describe the operation of a pump type air injection system.**

R Use transparency 1 to help you describe the operation of a pump type air injection system.

OBJECTIVE 4

Match the names of the parts of a pump type air injection system to descriptions of their functions.

R Allow the students to handle actual pump type air injection system parts as you describe the function of each.

OBJECTIVE 5

Describe the operation of a pulse air injection system.

R Show the students actual pulse air injection system parts as you describe the operation of the system.

OBJECTIVE 6

Inspect and test components of an air injection system. (Job Sheet 1)

R See the general instructions for all Job Sheets.

O Encourage the students to make individual reference notebooks from Job Sheet assignments. Grade these notebooks at the end of the unit. Encourage them to review the notebook before certification testing.

OBJECTIVE 7

Remove, service, and replace the components of an air injection system. (Job Sheet 2)

R See the general instructions for all Job Sheets.

O Divide the students into groups. Have each group read and organize the procedures for the Job Sheet from different vehicle service manuals. Have each group give a verbal presentation of their procedure to the other groups. Discuss any similarities and differences in procedure that vary with individual manufacturers.

OBJECTIVE 8

Inspect, test, service, and replace pump unit components. (Job Sheet 3)

R See the general instructions for all Job Sheets.

OBJECTIVE 9

Inspect, test, and replace vacuum-operated air control valves and vacuum hoses. (Job Sheet 4)

R See the general instructions for all Job Sheets.

OBJECTIVE 10

Inspect and replace electrical/electronic-operated components and circuits. (Job Sheet 5)

R See the general instructions for all Job Sheets.

O Give students a bonus quiz made up of questions relating to electrical/electronic information contained in the Introduction to Automotive Service curriculum. Choose information for the quiz based on its relevance to this Job Sheet.

OBJECTIVE 11

Test the operation of an air injection system. (Job Sheet 6)

R See the general instructions for all Job Sheets.

O Divide the students into groups. Have each group read and organize the procedures for the Job Sheet from different service manuals. Have each group give a verbal presentation of their procedure to the other groups. Discuss any similarities and differences in procedure that vary with individual manufacturers.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.
- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skill test.
- Describe the rating scale used on the skill test.
- Reteach and retest as necessary.
- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The item marked with an asterisk is included in the Instructor's Resource Package.

Publications

- Simanaitis, Dennis. "Tech Tidbits." *Road and Track*, July 1993, pp. 132-133.
- *Air Injection System Diagnosis Chart*. Handout.*

UNIT REFERENCES

Publications

- Bono, Saverio G. and William J. deKryger. *Auto Technology: Theory & Service*, (2nd ed.). Albany, NY: Delmar Publishers, Inc., 1990.

  —. *Auto Technology: Theory & Service, Student Service Manual*, (2nd ed.). Albany, NY: Delmar Publishers, Inc., 1990.

- Duffy, James E. *Modern Automotive Mechanics*. South Holland, IL: Goodheart-Willcox Co., Inc., 1990.

- Erjavec, Jack and Robert Scharff. *Automotive Technology: A Systems Approach*. Albany, NY: Delmar Publishers, Inc., 1992.

  —. *Tech Manual to Accompany Automotive Technology: A Systems Approach*. Albany, NY: Delmar Publishers, Inc., 1992.

- Layne, Ken. *Automotive Engine Performance Tuneup, Testing, and Service Practice Manual*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1986.

- Scharff, Robert and the Editors of Motor Service. *Complete Fuel Systems and Emission Control*. Albany, NY: Delmar Publishers, Inc., 1989.

  —. *Complete Fuel Systems and Emission Control. Student Technician's Shop Manual*. Albany, NY: Delmar Publishers, Inc., 1989.

SERVICING AIR INJECTION SYSTEMS

WRITTEN TEST

OBJECTIVE 1

An air injection system reduces harmful exhaust emissions by forcing fresh air into the exhaust system.

OBJECTIVE 2

1. hose (to exhaust manifold ports)
2. air pump
3. hose (to catalytic converter)
4. hose
5. diverter valve
6. check valves

OBJECTIVE 3

A pump type air injection system forces fresh air into either the exhaust manifold or the dual bed catalytic converter. Added to the exhaust manifold, the air causes the unburned fuel in the exhaust to burn in the hot exhaust manifold. Added to the catalytic converter, the additional air is used to mix with the harmful exhaust emissions to form harmless exhaust by-products such as water, carbon dioxide, and oxygen.

OBJECTIVE 4

1. A
2. C
3. B

OBJECTIVE 5

In a pulse air injection system, a spring-loaded check valve, sometimes called a *reed valve* or an *aspirator valve*, is located in a hose connecting the air cleaner to the exhaust manifold and the catalytic converter. Negative pressure pulses from the normal operation of these exhaust components pull fresh air through the valve into the exhaust manifold and the catalytic converter. Positive pressure pulses cause the valve to close, keeping the hot exhaust gases from backing up inside the hose.

OBJECTIVE 6

Evaluated on Job Sheet 1.

OBJECTIVE 7	**Evaluated on Job Sheet 2.**
OBJECTIVE 8	**Evaluated on Job Sheet 3.**
OBJECTIVE 9	**Evaluated on Job Sheet 4.**
OBJECTIVE 10	**Evaluated on Job Sheet 5.**
OBJECTIVE 11	**Evaluated on Job Sheet 6.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 13 — SERVICING AIR INJECTION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 13

TOTAL NUMBER OF BASIC SKILL QUESTIONS 6

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1	W
2	1-7	X
3	1	W, S
4	1-3	S
5	1	W, S
6	Evaluated on JS 1	
7	Evaluated on JS 2	
8	Evaluated on JS 3	
9	Evaluated on JS 4	
10	Evaluated on JS 5	
11	Evaluated on JS 6	

INSTRUCTOR'S
GUIDE

SERVICING HEATED AIR INDUCTION SYSTEMS

14

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Philip H. Abelson's editorial, "Automotive Fuel Efficiency," in *Science* magazine, September 1992, p. 1459.

Writing

R Have the students write a short (one paragraph to one page) explanation of how manufacturers could make vehicles more fuel efficient and how they believe consumers would react to those changes.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **State the function of a heated air induction system.**

OBJECTIVE 2 **Label the parts of a heated air induction system indicated on an illustration.**

R Point out these same components on an actual vehicle.

OBJECTIVE 3 **Describe the operation of a heated air induction system.**

R Use transparency 1 to help you explain how the parts of a heated air induction system work.

OBJECTIVE 4

Test the operation of a heated air induction system. (Job Sheet 1)

- R Explain to the students why it is best to inspect and test the heated air induction system on an annual basis, just before cold weather begins.
- R See the general instructions for all Job Sheets.

OBJECTIVE 5

Inspect and replace a heat stove shroud and hot air pipe of a heated air induction system. (Job Sheet 2)

- R See the general instructions for all Job Sheets.

OBJECTIVE 6

Inspect, test, and replace sensors, diaphragms, the damper, and hoses of a heated air induction system. (Job Sheet 3)

- R See the general instructions for all Job Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.
- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.
- Describe the rating scale used on the skills test.
- Reteach and retest as necessary.
- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.
- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The item marked with an asterisk is included in the Instructor's Resource Package.

Publications

- Abelson, Philip H. "Automotive Fuel Efficiency." *Science*, September 1992, p. 1459.
- *Heated Air Induction System Diagnosis Chart*. Handout. *

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach.* Stillwater, OK. CIMC, Oklahoma Department of Vocational and Technical Education, 1992. For ordering information call 800-522-5810.

UNIT REFERENCES

Publications

- Bono, Saverio G. and William J. deKryger. *Auto Technology, Theory & Service.* Albany, NY: Delmar Publishers Inc., 1990.
- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics.* New York: Macmillian/McGraw-Hill, 1993.
- Duffy, James E. *Auto Engines.* South Holland, IL: Goodheart-Willcox Co., Inc., 1988.

  —. *Modern Automotive Mechanics.* South Holland, IL: Goodheart-Willcox Co., Inc., 1985.
- Erjavec, Jack and Robert Scharff. *Automotive Technology: A Systems Approach.* Albany, NY: Delmar Publishers, Inc., 1992.

ANSWERS

SERVICING HEATED AIR INDUCTION SYSTEMS

14

WRITTEN TEST

OBJECTIVE 1

The heated air induction system improves engine performance and reduces emissions by decreasing engine warm-up time and keeping the temperature of the air entering the engine constant.

OBJECTIVE 2

1. air temperature sensor
2. air cleaner
3. heat stove shroud
4. exhaust manifold
5. hot air pipe
6. snorkel
7. vacuum motor
8. damper

OBJECTIVE 3

The air temperature sensor checks the temperature of air entering the air cleaner. If the air is too cool, the air temperature sensor activates a vacuum motor which pulls up the damper in the snorkel, allowing heated air coming through the heat stove shroud to blend with the cooler air.

OBJECTIVE 4

Evaluated on Job Sheet 1.

OBJECTIVE 5

Evaluated on Job Sheet 2.

OBJECTIVE 6

Evaluated on Job Sheet 3.

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 14 — SERVICING HEATED AIR INDUCTION SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 10

TOTAL NUMBER OF BASIC SKILL QUESTIONS 2

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1	W
2	1-8	X
3	1	W, S
4	Evaluated on JS 1	
5	Evaluated on JS 2	
6	Evaluated on JS 3	

INSTRUCTOR'S
GUIDE

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

15

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Mark Rechtin's article, "Breathing Easy: California Leads Race to Quell Car Pollution," in *Automotive News*, September 21, 1993, pp. 152-153.

Writing

R Have the students write one or two paragraphs explaining how competition in emission research benefits our environment.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **State the function of a manifold heat control system.**

OBJECTIVE 2 **Describe how the manifold heat control system usually achieves its function.**

R Explain the operation of a heat chamber to the students.

R Review the function of the intake manifold with the students.

OBJECTIVE 3 **Name the types of manifold heat control systems shown in illustrations.**

R See the material for objective 5.

OBJECTIVE 4

State the location where each type of manifold heat control system is installed.

R See the material for objective 5.

OBJECTIVE 5

Match the names of types of manifold heat control systems to descriptions of their operation.

R Show the students transparencies 1-3, and discuss the location and operation of each type of manifold heat control systems to the students.

OBJECTIVE 6

Inspect, test, repair, and replace components of a manifold heat control system. (Job Sheet 1)

R Show the students the location of the manifold heat control systems in several makes and models of vehicles.

R See the general instructions for all Job Sheets.

OBJECTIVE 7

Test the operation of a manifold heat control system. (Job Sheet 2)

R See the general instructions for all Job Sheets.

OBJECTIVE 8

Inspect, service, and replace a manifold heat control valve. (Job Sheet 3)

R Show the students the location of a heat control valve in several makes and models of vehicles.

R See the general instructions for all Job Sheets.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.
- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.

- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.

- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.

- Complete the appropriate sections of the Competency Profiles.

- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The item marked with an asterisk is included in the Instructor's Resource Package.

- *Manifold Heat Control System Diagnosis Chart*, Handout*
- Rechtin, Mark. "Breathing Easy: California Leads Race to Quell Car Pollution." *Automotive News*, September 21, 1993, pp. 152-153.

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach.* Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 1992. For ordering information call 800-522-5810.

UNIT REFERENCES

Publications

- Anglin, Donald L. and William H. Crouse. *Motor Vehicle Inspection.* New York: McGraw- Hill, Gregg Division, 1978.
- Bono, Saverio and William J. de Kryger. *Automotive Technology: Theory and Service,* (2nd ed.). Albany, NY: Delmar Publishers, Inc., 1990.
- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics*, (9th ed.). New York: McGraw-Hill, 1985.
- de Kryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service.* Cincinnati, OH: South-Western Publishing Co., 1980.
- Gilles, Tim. *Automotive Engines: Diagnosis, Repair, and Rebuilding*, (2nd ed.). Albany, NY: Delmar Publishers, Inc., 1991.
- Stockel, Martin W. and Martin T. Stockel. *Auto Service and Repair.* South Holland, IL: Goodheart-Willcox Co., Inc., 1984.
- Toboldt, William K. et. al. *Automotive Encyclopedia*, (rev. ed.). South Holland, IL: Goodheart-Willcox, 1989.

ANSWERS

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

15

WRITTEN TEST

OBJECTIVE 1	A manifold heat control system increases fuel efficiency by heating the air-fuel mixture in a cold engine.
OBJECTIVE 2	The manifold heat control system warms the air-fuel mixture in the intake manifold by circulating hot exhaust gases in a special heat chamber constructed to surround the outside wall of the intake manifold.
OBJECTIVE 3	1. early fuel evaporation (EFE) vacuum type system with a thermal vacuum switch 2. mechanical type heat control valve system 3. early fuel evaporation (EFE) electric grid type system
OBJECTIVE 4	1. between the exhaust manifold and the exhaust pipe 2. between the exhaust manifold and the exhaust pipe 3. most often found mounted between the carburetor or the throttle body and the intake manifold
OBJECTIVE 5	1. C 2. B 3. A
OBJECTIVE 6	**Evaluated on Job Sheet 1.**
OBJECTIVE 7	**Evaluated on Job Sheet 2.**
OBJECTIVE 8	**Evaluated on Job Sheet 3.**

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 15 — SERVICING MANIFOLD CONTROL SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 11

TOTAL NUMBER OF BASIC SKILL QUESTIONS 5

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1	W,S
2	1	W,S
3	1-3	X
4	1-3	X
5	1-3	S
6	Evaluated on JS 1	
7	Evaluated on JS 2	
8	Evaluated on JS 3	

INSTRUCTOR'S GUIDE

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

Required Activities and Resources (R)

These are fully integrated components of this CIMC curriculum. They are usually packaged in or with the curriculum and are essential in meeting the learning objectives. To individualize this unit, use the LAP Sheet supplied in your resources.

- Reproducible Handouts and Transparency Masters are included in the Instructor's Resource Package. Handouts should be copied for all students. Transparency Masters should be used to make overhead transparencies for use during instruction. A small copy of each Transparency Master appears in the student's Information Sheets.
- Non-reproducible resources are included in the student's curriculum.

Optional Activities and Resources (O)

These are suggested high-interest activities to help deliver learning objectives to students or to let students achieve objectives in an applied context. Select as many as you wish to use. Some activities use extra resources for further information about unit content. You can make them available in the classroom for in-depth study or optional activities, but their use is not required for meeting CIMC unit objectives.

FOCUS ASSIGNMENTS

Prereading

R Have the students read Dan McCosh's article, "Auto Tech 1994 — Power for the Future," in *Popular Science* magazine, October 1993, pp. 84-87, 118. Tell them to pay special attention to the improvement of emission control on these smaller engines.

Writing

R Have the students write a one page summary of the article, telling how engines have improved over pre-emission control engines, why engines are being redesigned, and the regulations responsible for these changes.

GENERAL INSTRUCTIONS

Assignment Sheets

R Review the directions and any specific guidelines.

R Make certain that any needed materials from the Instructor's Resource Package are available.

R Have the students complete the Assignment Sheet. Evaluate each student's performance and provide reteaching and retesting as necessary. Have the students repeat the Assignment Sheet until they achieve mastery.

R Complete each student's Competency Profile.

O Have the students volunteer to read aloud the directions and any special guidelines.

O Return the completed Assignment Sheets to the students so that they may use them for later reference if needed.

Job Sheets

R Review the introduction and evaluation criteria for the Job Sheet. Remind the students that they should not fill in the blanks in the Yes/No columns.

R Review and explain all general guidelines, safety cautions, and warnings.

R Discuss any unique safety rules the students will need to follow in performing the procedures in the Job Sheet. Test the students in the performance of these procedures if appropriate.

R Show the students the location of any safety equipment and materials which may be required in the performance of the Job Sheet. Test the students in the use of this equipment and materials if appropriate.

R Make sure that all tools, equipment, and supplies are available.

R Show the students examples, both functioning and defective, of the vehicle components and parts covered by the Job Sheet.

R Demonstrate how to operate any equipment that will be used in the Job Sheet. Test the students in the use of this equipment if appropriate.

R Show the students how to locate the procedure in an appropriate service manual. Do this even if the Job Sheet provides a procedure for the student to follow in performing the Job Sheet.

R Demonstrate each of the procedures outlined in the Job Sheet.

R Allow the students to practice the Job Sheet skills before skills testing. Coach, correct, and supervise as necessary.

R Have the students complete the Job Sheet. Evaluate each student's performance and provide remediation as necessary. Have the students repeat the Job Sheet until they achieve mastery.

R Complete each student's Competency Profile.

R Return the completed Job Sheets to the students so that they may use them for later reference if needed.

O Have the students volunteer to read aloud the job guidelines, cautions, and warnings.

LAP Sheets

The LAP Sheets are an optional component that can be used to individualize instruction. The following instructions should be followed only if you are using the LAP Sheets.

R Explain the specific procedures to be followed to the students before they begin using the LAP Sheet. Be sure that each student understands the procedures for using the LAP Sheet.

R If you want the student to complete any of the assignments on the LAP Sheet that are labeled optional, assign these to the student. Be sure to provide any needed resources.

OBJECTIVE 1 **State the function of a fuel vapor control system.**

O Have the students experience vaporization by dabbing rubbing alcohol on their hand and letting them observe how quickly it evaporates from the warmth of the hand.

OBJECTIVE 2 **Label the parts of a fuel vapor control system indicated on an illustration.**

OBJECTIVE 3 **Match the names of the parts of a fuel vapor control system to descriptions of their functions.**

R Use the transparency to illustrate a fuel vapor control system while you explain the function of the parts.

R Pass parts of a fuel vapor control system around so the students can examine them.

OBJECTIVE 4 **Describe the operation of a fuel vapor control system.**

OBJECTIVE 5 **Test the operation of a fuel vapor control system. (Job Sheet 1)**

R See the general instructions for all Job Sheets.

O Explain how the pressure-vacuum gas tank caps play a vital role in fuel vapor control system operation. Let the students examine and compare actual pre-emission and post-emission gas tank caps, noting the effect the design changes have had on vehicle emissions.

OBJECTIVE 6 **Inspect, test, and replace thermal, vacuum, and electrical controls of a fuel vapor control system. (Job Sheet 2)**

R See the general instructions for all Job Sheets.

OBJECTIVE 7 **Inspect, service, and replace the components of a fuel vapor control system. (Job Sheet 3)**

R See the general instructions for all Job Sheets.

OBJECTIVE 8 **Diagnose engine mechanical, ignition, fuel, and emission control problems with an exhaust gas analyzer. (Assignment Sheet)**

R See the general instructions for all Assignment Sheets.

O Ask a local service manager to speak to the students about continuing education in emissions service for Engine Performance Technicians. Encourage the students to ask questions about the frequency and type of training required.

EVALUATION

Pretest

- Use the unit Written Test for *both* the pretest and posttest. Give the students the pretest before they begin the unit.

- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving pretests and using the results. Information for ordering this material is included in the optional resources section.

- Use pretest results to guide individual students in progressing through the unit, doing enrichment work, or moving to the next unit.

Focus Assignment

- Use an informal evaluation of the focus assignments as a diagnostic tool for determining if any students need extra help in reading comprehension or writing skills. Refer these students to their English instructor, Learning Resource Center, or Educational Enhancement Center.

Assignment Sheet

- Evaluate students on Assignment Sheet activities. Students must repeat an Assignment Sheet until they have mastered the activity.

- Complete each student's Competency Profile.

Skill Test

- Explain to the students that they will be asked to demonstrate the procedures on the Job Sheets as a skills test.

- Describe the rating scale used on the skills test.

- Reteach and retest as necessary.

- Complete each student's Competency Profile.

Posttest

- After they have completed the unit, give students the Written Test again.

- Explain to the students that they will be asked to demonstrate on the Written Test actions listed in the specific objectives.
- You may wish to use the CIMC publication *Measuring Learning and Competency Gains: The Pretest/Posttest Approach* for instructions and suggestions on giving posttests and using the results. Information for ordering this material is included in the optional resources section.
- Reteach and retest as necessary to meet individual student needs and state standards for student learning and competency gains.
- Complete the appropriate sections of the Competency Profiles.
- Review individual and group performance to evaluate teaching effectiveness. Adjust scope, sequence, or instructional methods for additional lessons as required.

REQUIRED RESOURCES

The items marked with an asterisk are included in the Instructor's Resource Package.

Publications

- *Carbon Monoxide (CO) Exhaust Level Diagnosis.* Handout 4.*
- *Exhaust Gas Analysis Parameters for HC, CO, CO_2, and O_2.* Handout 2.*
- *How Vehicle Emissions are Affected by Gasoline.* Handout 6.*
- *Hydrocarbon (HC) Exhaust Level Diagnosis.* Handout 3.*
- McCosh, Dan. "Auto Tech 1994 — Power for the Future." *Popular Science*, Vol. 243, No. 4, October 1993, pp. 84-87, 118.
- *Oxygen (O_2) Exhaust Level Diagnosis.* Handout 5.*
- *Vehicle Emissions.* Handout 1.*

OPTIONAL RESOURCES

Publications

- *Measuring Learning and Competency Gains: The Pretest/Posttest Approach.* Stillwater, OK: CIMC, Oklahoma Department of Vocational and Technical Education, 1992. For ordering information call 800-522-5810.

UNIT REFERENCES

Publications

- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics*, 10th ed. Westerville, OH: Glencoe Division, McGraw-Hill School Publishing Co., 1993.
- deKryger, William J. and Saverio G. Bono. *Auto Technology: Theory and Service*, 2nd ed. Albany, NY: Delmar Publishers, Inc., 1990.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, IL: Goodheart-Willcox Co., Inc., 1990.
- Erjavec, Jack. and Robert Scharff. *Automotive Technology*. Albany, NY: Delmar Publishers, Inc., 1992.
- Layne, Ken. *Automotive Engine Performance Practice Manual*. Englewood Cliffs, NJ: Prentice-Hall Publishing Co., 1986.
- McCosh, Dan. "Auto Tech 1994 — Power for the Future." *Popular Science*, Vol. 243, No. 4, October 1993, pp. 84-87, 118.

ANSWERS

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

ASSIGNMENT SHEET

OBJECTIVE 8

Assignment Sheet

1. A
2. B
3. C
4. D
5. B
6. D
7. C
8. A
9. B
10. D
11. A
12. C
13. B
14. B
15. A. oxygen sensor
    B. air injection system

WRITTEN TEST

OBJECTIVE 1

A fuel vapor control system prevents pollution and increases vehicle fuel economy by preventing fuel vapors from escaping directly into the atmosphere.

OBJECTIVE 2

1. fuel tank
2. pressure-vacuum cap
3. roll-over valve
4. fuel tank vent line
5. charcoal canister
6. canister purge solenoid valve
7. canister purge line

OBJECTIVE 3

1. D
2. G
3. B
4. A
5. C
6. E
7. F

OBJECTIVE 4

When the engine is turned off, fuel vapors from the intake manifold and the fuel tank flow into the charcoal canister where they are stored. When the engine is started, the vacuum in the intake manifold draws fresh air through the charcoal canister, carrying the stored fuel vapors into the intake manifold where they are used as part of the air-fuel mixture burned by the engine.

OBJECTIVE 5

Evaluated on Job Sheet 1.

OBJECTIVE 6

Evaluated on Job Sheet 2.

OBJECTIVE 7

Evaluated on Job Sheet 3.

OBJECTIVE 8

Evaluated on the Assignment Sheet.

CIMC
TEST CODE SHEET

VOCATIONAL PROGRAM (BOOK TITLE) ENGINE PERFORMANCE SPECIALIST

UNIT NUMBER AND TITLE 16 — SERVICING FUEL VAPOR CONTROL SYSTEMS

TOTAL NUMBER OF TEST QUESTIONS 16

TOTAL NUMBER OF BASIC SKILL QUESTIONS 9

OBJECTIVE NUMBER	TEST QUESTION NUMBER(S)	BASIC SKILL CODE(S)
1	1	W
2	1-7	X
3	1-7	S
4	1	W, S
5	Evaluated on JS 1	
6	Evaluated on JS 2	
7	Evaluated on JS 3	
8	Evaluated on AS	

Engine Performance Specialist

Instructor's Resource Package

LAP Sheets

Transparency Masters

Written Tests

Handouts

Developed by the
Curriculum and Instructional Materials Center
for the Division of **Trade and Industrial Education**
Oklahoma Department of Vocational and Technical Education

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LAP
SHEET

UNDERSTANDING ENGINE FUNDAMENTALS

1

Name ______________________________

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

2. **Read** ____ the introduction, unit objective, and specific objectives.

3. **Do** ____ the focus assignments.

4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.

5. **Study** ____ the Information Sheet, objective 1.

6. **Participate** ____ in a discussion on the safety hazards listed.

7. **Study** ____ the Information Sheet, objective 2.

8. **Ask** ____ your instructor to explain the chemical hazards that exist when working on the engine systems.

Optional: Take ____ a quiz on the information contained in your instructor's explanation of the chemical hazards in working on engine systems.

9. **Study** ____ the Information Sheet, objectives 3 and 4 .

10. **Ask** ____ your instructor to explain the functions of the engine systems.

11. **Ask** ____ your instructor to point out the components of different engine systems on a vehicle.

12. **Study** ____ the Information Sheet, objectives 5 and 6.

May be photocopied for student use.

13. **Ask** _____ your instructor to explain what happens inside the engine during each of the four strokes.

Optional: Look _____ at a model of an engine cylinder to help you understand the four strokes.

14. **Sketch** _____ the spark in the correct engine stroke. Use Figure 1.

15. **Check** _____ your work using transparency 2 or the Handout.

16. **Stop** _____ and have your instructor check your drawing.

17. **Ask** _____ your instructor to explain the terms in the Words You Should Know box in objective 8.

18. **Sketch** _____ the piston in the correct position for each engine stroke. Use Figure 1.

19. **Check** _____ your work using transparency 3 or the Handout.

20. **Stop** _____ and have your instructor check your drawing.

21. **Draw** _____ an arrow showing the direction of piston movement for each engine stroke. Use Figure 1.

22. **Check** _____ your work using transparency 4 or the Handout.

23. **Stop** _____ and have your instructor check your drawing.

24. **Sketch** _____ the intake valve in the correct position for each engine stroke. Use Figure 1.

25. **Check** _____ your work using transparency 5 or the Handout.

26. **Stop** _____ and have your instructor check your drawing.

27. **Sketch** _____ the exhaust valve in the correct position for each engine stroke. Use Figure 1.

28. **Check** _____ your work using transparency 6 or the Handout.

29. **Stop** _____ and have your instructor check your drawing.

30. **Study** _____ the Information Sheet, objective 12.

Optional: Write _____ a report on one of the emission control systems listed.

May be photocopied for student use.

31. Take

____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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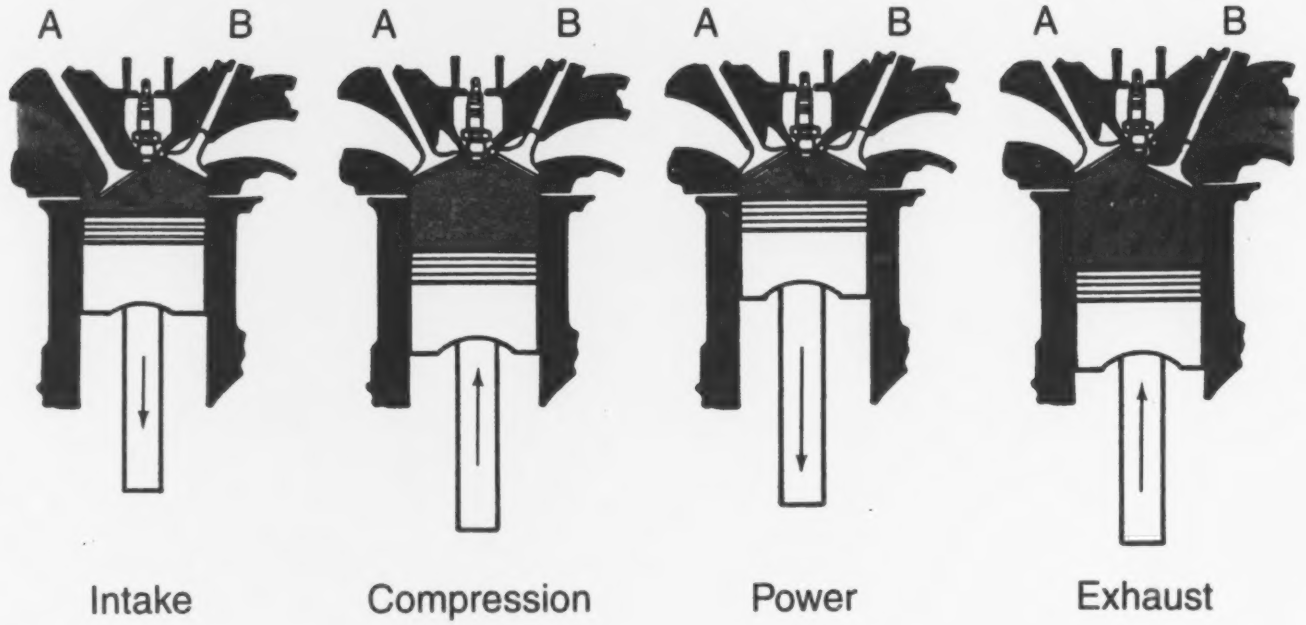
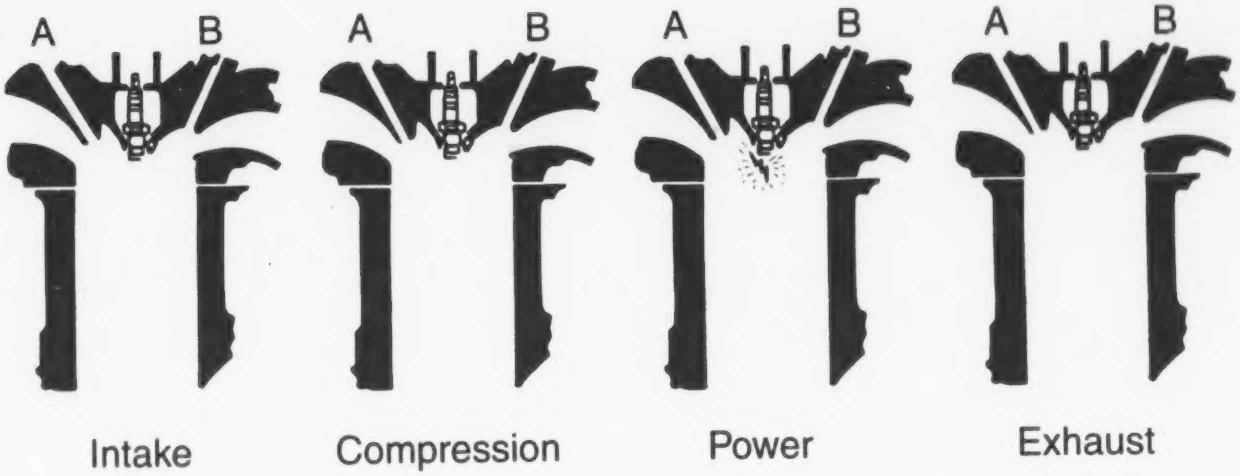
Four Strokes of an Internal Combustion Engine


A
B
A
B
A
B
A
B
Intake
Compression
Power
Exhaust

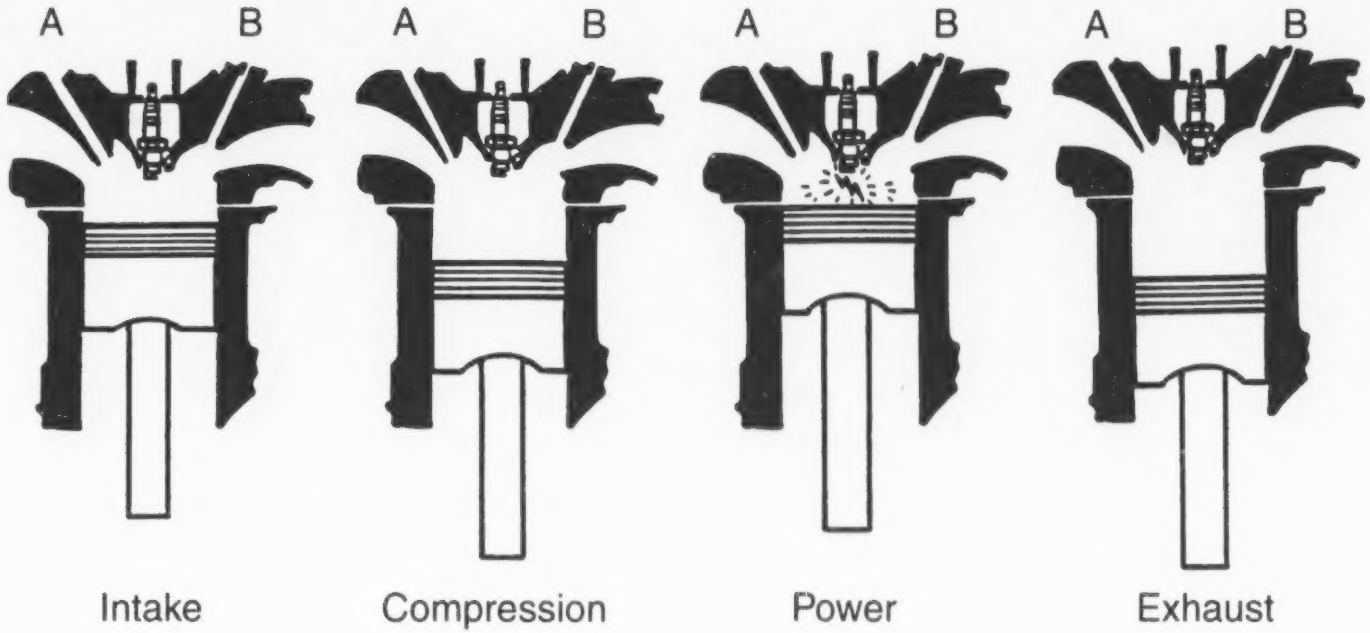
May be photocopied for student use

Spark


A
B
A
B
A
B
A
B
Intake
Compression
Power
Exhaust

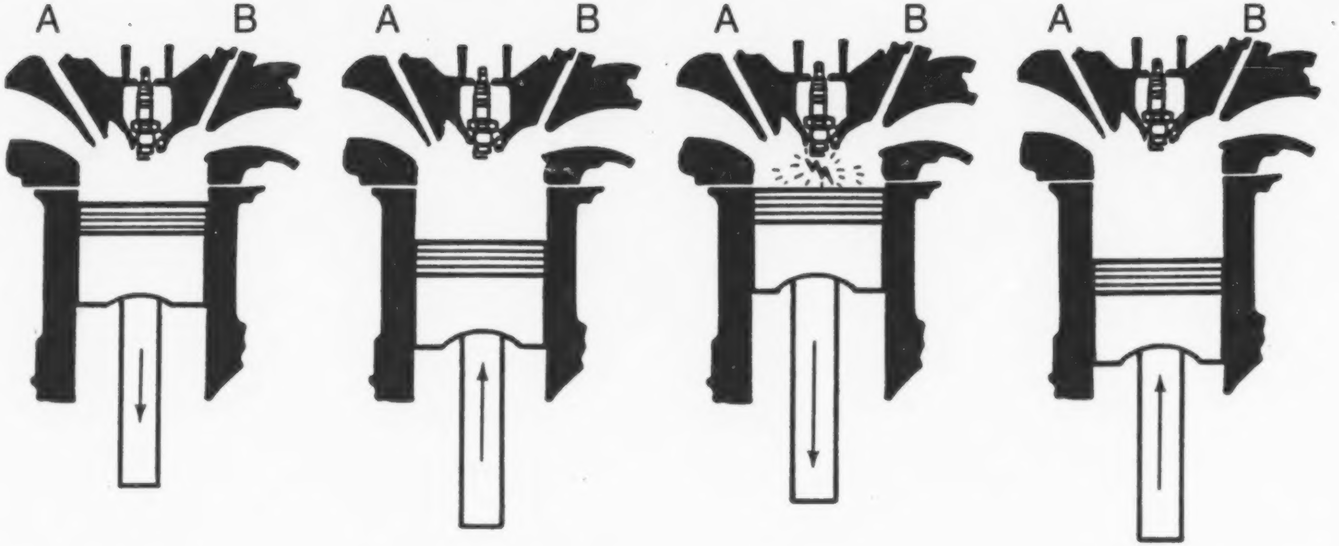
May be photocopied for student use

Spark and Piston Position


A
B
A
B
A
B
A
B
Intake
Compression
Power
Exhaust

May be photocopied for student use

Spark, Piston Position, and Piston Movement



Intake Compression Power Exhaust

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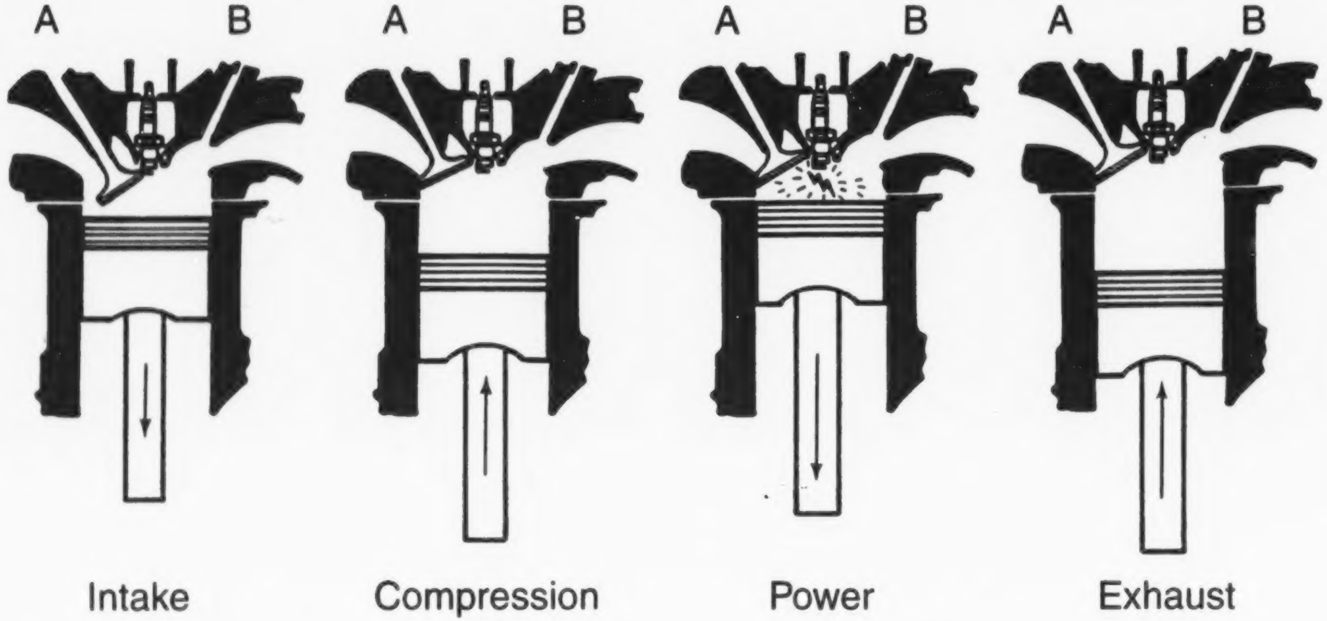
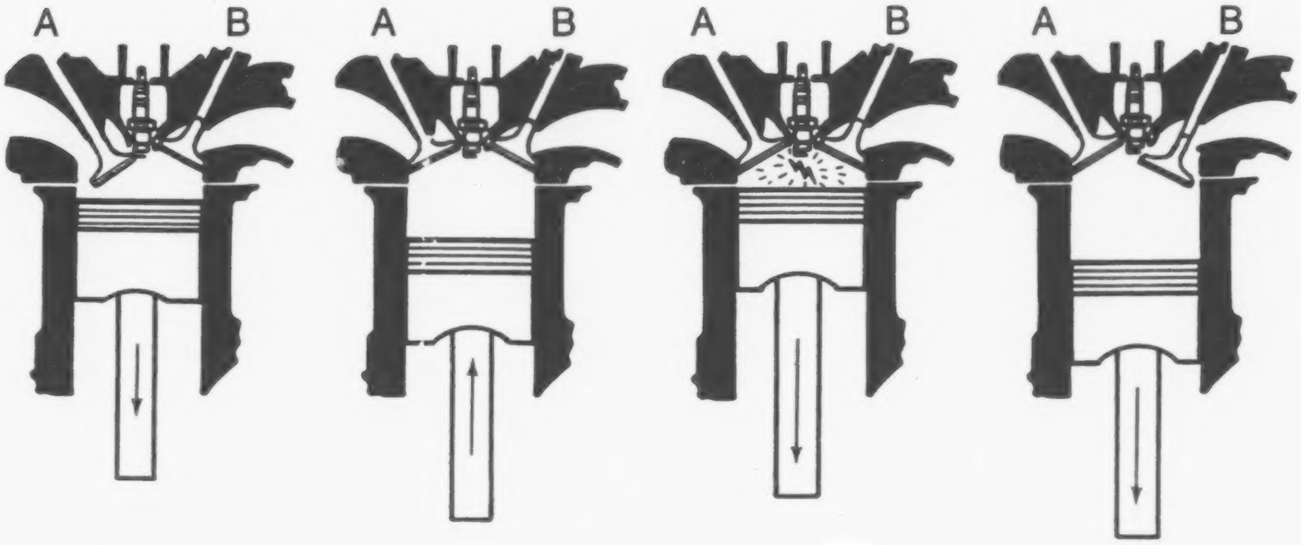
INSTRUCTOR'S RESOURCE PACKAGE - Engine Performance Specialist
TRANSPARENCY MASTER 4 - **CIMC** 1.1

Spark, Piston Position, Piston Movement, and Intake Valve Position


A
B
A
B
A
B
A
B
Intake
Compression
Power
Exhaust

May be photocopied for student use

Spark, Piston Position, Piston Movement, Intake Valve Position, and Exhaust Valve Position



Intake Compression Power Exhaust

May be photocopied for student use

WRITTEN TEST

UNDERSTANDING ENGINE FUNDAMENTALS

1

Name ______________________________ Date _________ Score ____

OBJECTIVE 1

List safety hazards associated with engine performance work. List the hazards in the spaces provided.

1. ____
2. ____
3. ____
4. ____

OBJECTIVE 2

List automotive sources related to engine service which contain hazardous chemicals. List the sources in the spaces provided.

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____

OBJECTIVE 3

List the names of engine systems. List the names of engine systems in the spaces provided under objective 4.

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OBJECTIVE 4

Describe the functions of engine systems. Describe the functions of engine systems in the spaces provided below.

1. Engine system: ____________________

   Function: ____________________

   ____

2. Engine system: ____________________

   Function: ____________________

   ____

3. Engine system: ____________________

   Function: ____________________

   ____

4. Engine system: ____________________

   Function: ____________________

   ____

5. Engine system: ____________________

   Function: ____________________

   ____

6. Engine system: ____________________

   Function: ____________________

   ____

7. Engine system: ____________________

   Function: ____________________

   ____

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OBJECTIVE 5

List three elements that must be present in order for combustion to occur. Write the three elements in the blanks below.

1. ______________________________

2. ______________________________

3. ______________________________

OBJECTIVE 6

List the four strokes of an internal combustion engine in the order of their occurrence. List the four strokes in order. You may begin with any stroke, but the next stroke you list must be the one that would follow it in order of occurrence.

1. ______________________________

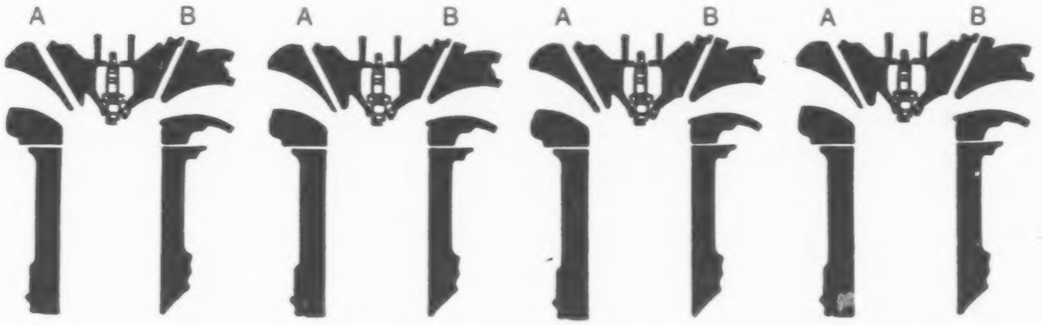
2. ______________________________

3. ______________________________

4. ______________________________

OBJECTIVE 7

Using illustrations of cylinders, sketch the spark in the correct engine stroke. Draw the spark in the correct engine stroke in the illustration below.



Intake Compression Power Exhaust

☑ **NOTE:** The position for the intake valve is labeled "A," the position for the exhaust valve is labeled "B."

OBJECTIVE 8

Using illustrations of cylinders, sketch the piston in the correct position for each of the four engine strokes. Draw the piston in the correct position for each engine stroke in the illustration in objective 7 on the previous page.

OBJECTIVE 9

Using illustrations of cylinders, draw an arrow to indicate the direction of piston movement for each of the four engine strokes. Draw an arrow to indicate the direction of piston movement for each engine stroke in the illustration in objective 7 on the previous page.

OBJECTIVE 10

Using illustrations of cylinders, sketch the intake valve in the correct position for each of the four engine strokes. Draw the intake valve in the correct position for each engine stroke in the illustration in objective 7 on the previous page.

OBJECTIVE 11

Using illustrations of cylinders, sketch the exhaust valve in the correct position for each of the four engine strokes. Draw the exhaust valve in the correct position for each engine stroke in the illustration in objective 7 on the previous page.

OBJECTIVE 12

List the names of emission control systems. List the names in the spaces provided.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________

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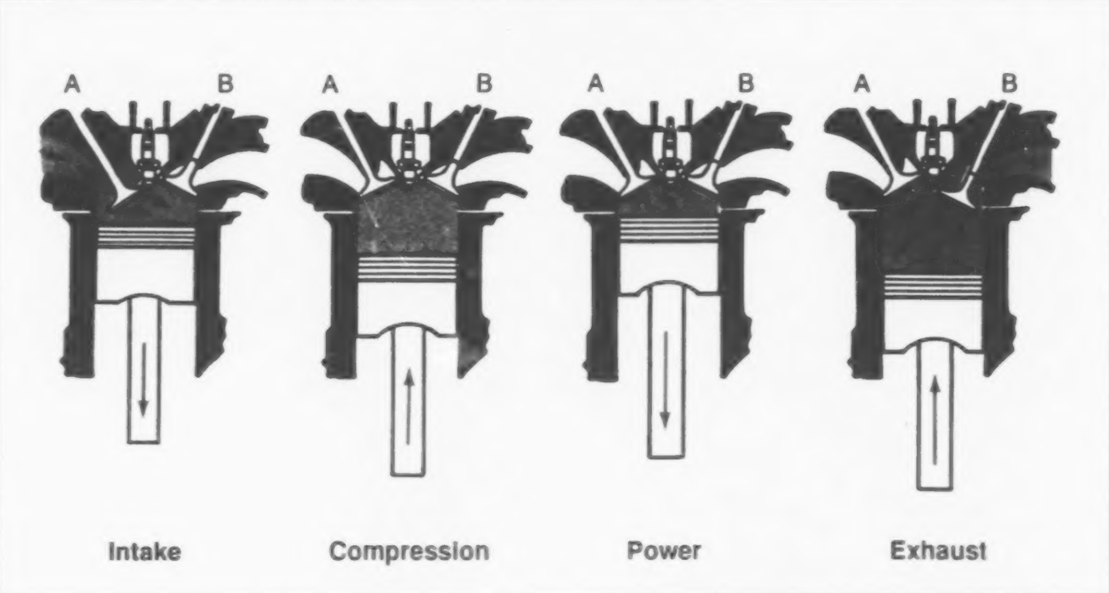
HANDOUT

UNDERSTANDING ENGINE FUNDAMENTALS

1

Four Strokes of an Internal Combustion Engine

FIGURE 1


A
B
A
B
A
B
A
B
Intake
Compression
Power
Exhaust

☑ **NOTE:** Intake valves are labeled "A," and exhaust vales are labeled "B."

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LAP SHEET

SERVICING STARTING AND CHARGING SYSTEMS

2

Name ____________________

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

2. **Read** ____ the introduction, unit objective, and specific objectives.

3. **Do** ____ the focus assignments.

4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.

5. **Study** ____ the Information Sheet, objectives 1 and 2.

6. **Ask** ____ your instructor to explain the factors that affect correct battery selection.

7. **Study** ____ the introduction to Assignment Sheet 1.

8. **Ask** ____ your instructor to explain the information in Handouts 1 and 2 and Information Sheet objective 2.

9. **Do** ____ Assignment Sheet 1.

10. **Stop** ____ and have your instructor evaluate your work from Assignment Sheet 1. After your work has been evaluated, follow your instructor's recommendations.

11. **Study** ____ the introduction to Job Sheet 1.

12. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

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13. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

14. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

15. **Study** ____ the introduction to Job Sheet 2.

16. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

17. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

18. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

19. **Study** ____ the introduction to Job Sheet 3.

20. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

21. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

22. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

23. **Study** ____ the Information Sheet, objective 7.

24. **Ask** ____ your instructor to explain how the starting system parts shown in Figure 1 work together.

25. **Study** ____ the Information Sheet, objective 8.

26. **Ask** ____ your instructor to show you the parts of an actual starting system and explain the function of each part.

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27. **Study** ____ the Information Sheet, objectives 9, 10, and 11.

28. **Ask** ____ your instructor to explain the conditions evaluated by starting/charging system tests.

29. **Study** ____ the Information Sheet, objective 12.

30. **Ask** ____ your instructor to demonstrate how to hook up the starting/charging test equipment.

31. **Study** ____ the introduction to Job Sheet 4.

32. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

33. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

34. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

35. **Study** ____ the introduction to Job Sheet 5.

36. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 5. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

37. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

38. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

39. **Study** ____ the introduction to Job Sheet 6.

40. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 6. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

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41. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.
42. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.
43. **Study** ____ the introduction to Assignment Sheet 2.
44. **Ask** ____ your instructor to explain the information in Handout 3.
45. **Do** ____ Assignment Sheet 2.
46. **Stop** ____ and have your instructor evaluate your work from Assignment Sheet 2. After your work has been evaluated, follow your instructor's recommendations.
47. **Study** ____ the Information Sheet, objectives 17 and 18.
48. **Ask** ____ your instructor to explain how the charging system (shown in Figure 2) operates.
49. **Ask** ____ your instructor to explain how an alternator operates.
50. **Study** ____ the introduction to Job Sheet 7.
51. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 7. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.
52. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.
53. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.
54. **Study** ____ the introduction to Job Sheet 8.
55. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 8. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

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56. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

57. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

58. **Study** _____ the introduction to Assignment Sheet 3.

59. **Ask** _____ your instructor to explain the information in Handout 4.

60. **Do** _____ Assignment Sheet 3.

61. **Stop** _____ and have your instructor evaluate your work from Assignment Sheet 3. After your work has been evaluated, follow your instructor's recommendations.

62. **Take** _____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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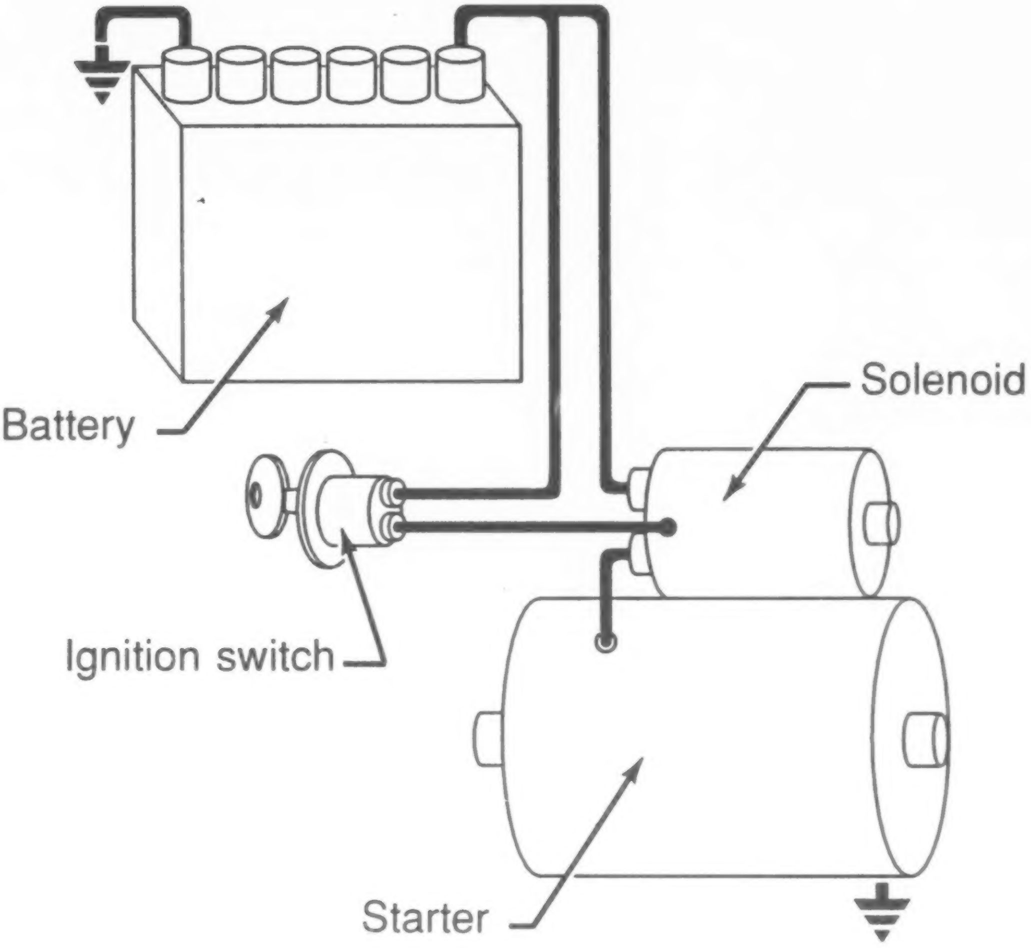
Parts of a Starting System


Battery
Solenoid
Ignition switch
Starter

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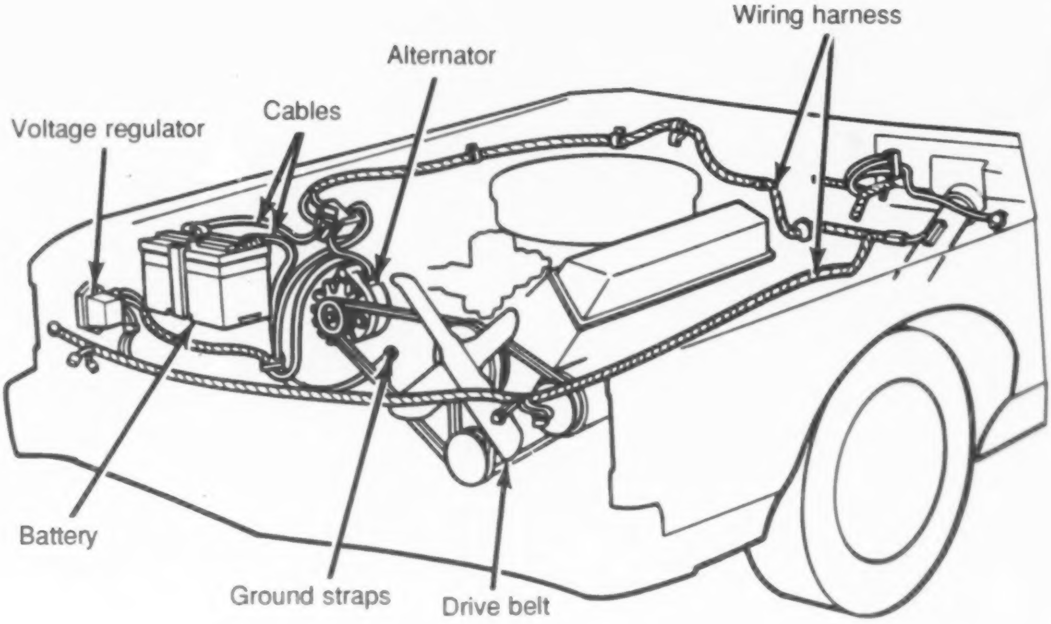
Parts of a Charging System


Wiring harness
Alternator
Cables
Voltage regulator
Battery
Ground straps
Drive belt

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WRITTEN TEST

SERVICING STARTING AND CHARGING SYSTEMS

2

Name ______________________________ Date _________ Score ___

OBJECTIVE 1

List safety rules for working with automobile batteries. Write your answers in the spaces provided.

1. ____
____
____

2. ____
____
____

3. ____
____
____

4. ____
____
____

OBJECTIVE 2

List factors affecting correct battery selection. Write your answers in the spaces provided.

1. ____
____

2. ____
____

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3. ______________________________

____

4. ______________________________

____

5. ______________________________

____

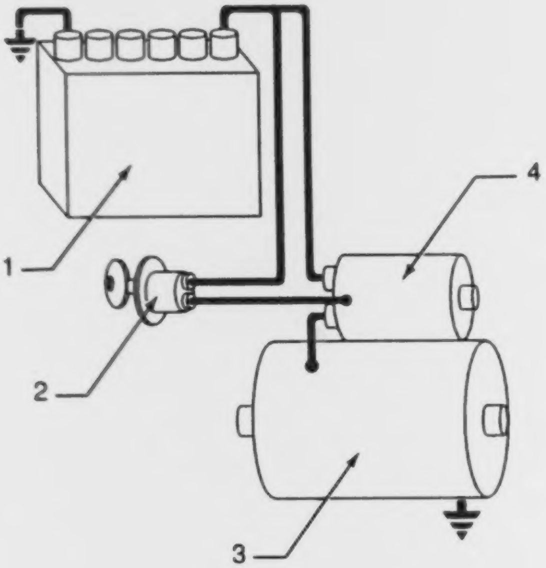
OBJECTIVE 3 **Evaluated on Assignment Sheet 1.**

OBJECTIVE 4 **Evaluated on Job Sheet 1.**

OBJECTIVE 5 **Evaluated on Job Sheet 2.**

OBJECTIVE 6 **Evaluated on Job Sheet 3.**

OBJECTIVE 7 **Label the parts of a starting system indicated on an illustration.** Write the name of the part on the line beside the appropriate number.



May be photocopied for student use.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

OBJECTIVE 8

Match the names of the parts of a starting system to descriptions of their functions. Write the letter of the correct answer in the blank to the left of the description.

A. battery
B. ignition switch
C. solenoid
D. starter

____ 1. Switches on and off the high voltage current which cranks the starter

____ 2. Provides electrical current for the starting, ignition, lighting, and other electrical components

____ 3. Opens and closes the circuit that transfers current from the battery to the solenoid

____ 4. Spins the flywheel to start the engine

OBJECTIVE 9

Arrange the steps of starting system operation in order. Place a "1" by the first step, a "2" by the second, and so on.

____ The starter's drive pinion gear begins to turn, moving the ring gear around the engine flywheel.

____ As the ignition key is turned, the solenoid switch closes, allowing high current to flow from the battery cables through the solenoid to the starter.

____ As the ring gear turns, it spins the crankshaft fast enough for the air-fuel mixture to enter the cylinders and start the engine.

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OBJECTIVE 10

List the components tested by starting/charging system tests. Write your answers in the spaces provided.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

OBJECTIVE 11

Match the names of starting/charging system tests with descriptions of the conditions evaluated by the tests. Write the letter of the correct answer in the blank to the left of the description.

A. alternator output test	C. circuit voltage drop test
B. battery high rate discharge test	D. starter draw test
	E. state-of-charge test

_____ 1. Checks the voltage level of the battery charge in batteries that do not have a charge indicator on the top

_____ 2. Measures the maximum current the alternator can produce at a specified voltage

_____ 3. Measures the lowest point to which the battery voltage drops while the battery is discharging at a high rate

_____ 4. Measures the current flow to the starting motor during engine cranking

_____ 5. Evaluates resistance across a cable, component, or connection during current flow

OBJECTIVE 12

Describe how starting/charging test equipment is hooked up to the vehicle. Write your answers in the spaces provided.

1. inductive amp gauge ______________________________

____

____

____

____

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2. multimeter voltmeter function ____________________

____

____

____

____

3. multimeter ohmmeter function ____________________

____

____

____

____

4. multimeter ammeter function ____________________

____

____

____

____

5. hydrometer ____________________

____

____

____

____

6. charging system/load tester ____________________

____

____

____

____

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OBJECTIVE 13 **Evaluated on Job Sheet 4.**

OBJECTIVE 14 **Evaluated on Job Sheet 5.**

OBJECTIVE 15 **Evaluated on Job Sheet 6.**

OBJECTIVE 16 **Evaluated on Assignment Sheet 2.**

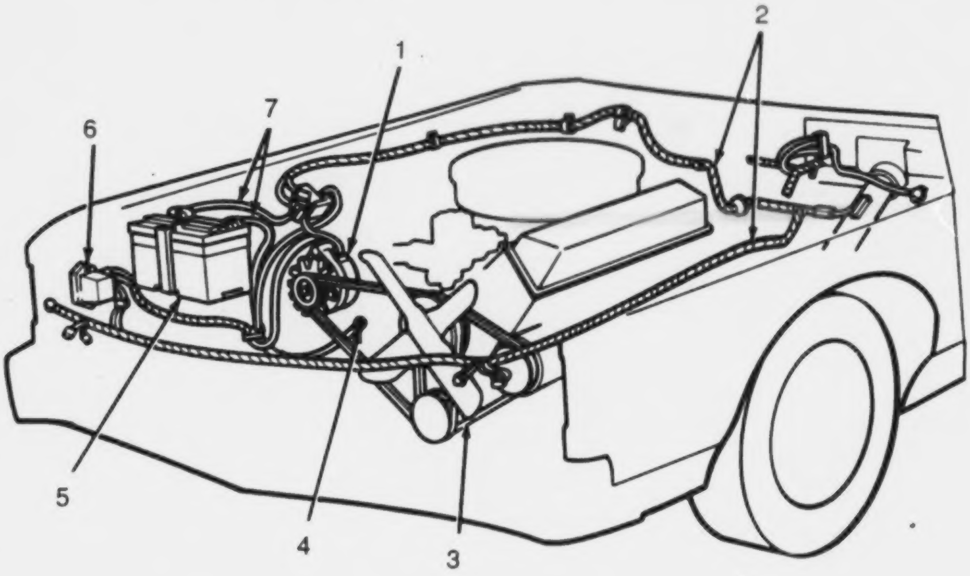
OBJECTIVE 17 **State the purpose of a charging system.** Write your answer in the space provided.

____

____

____

OBJECTIVE 18 **Label the parts of a charging system indicated on an illustration.** Write the name of the part on the line beside the appropriate number.



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1. ____

2. ____

3. ____

4. ____

5. ____

6. ____

7. ____

OBJECTIVE 19 **State the purpose of an alternator.** Write your answer in the space provided.

____

____

____

____

____

OBJECTIVE 20 **Evaluated on Job Sheet 7.**

OBJECTIVE 21 **Evaluated on Job Sheet 8.**

OBJECTIVE 22 **Evaluated on Assignment Sheet 3.**

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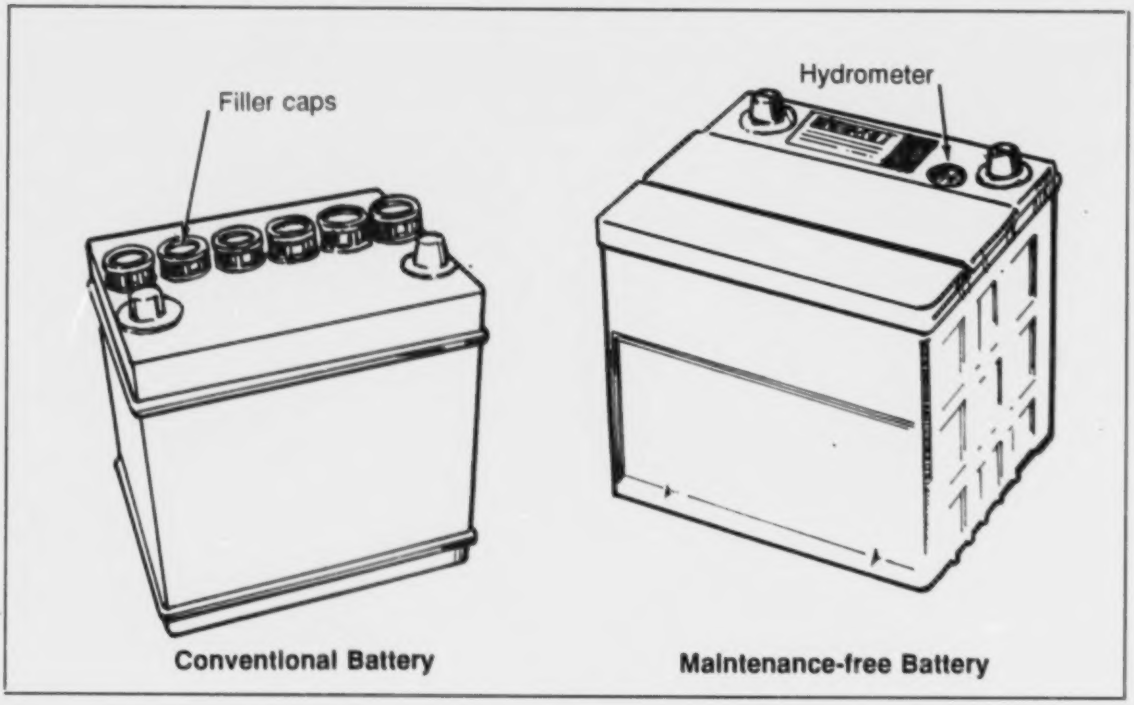
Choosing a New Battery

- **Battery Types**

FIGURE 1



Conventional batteries and maintenance-free (sealed) batteries work the same and are similar inside. The difference is that conventional batteries have filler caps and sometimes need extra distilled water. Maintenance-free batteries have sealed caps and should never need to have water added. They have a hydrometer on the top to show if the battery needs to be charged. Some batteries that are called maintenance-free have a fill hole where water can be added.

- **Battery Ratings**

Battery ratings show the expected performance of a battery.

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A rating in *Cold Cranking Amps* (CCA) shows how much current the battery can supply for 30 seconds at 0°F without dropping below 7.2 volts. The amount of current is measured in amps. The starting system needs a large current (lots of amps) to turn the engine, so knowing how much current the battery can give is useful. Batteries are weaker at lower temperatures, so it is also good to know what the battery will do when it is cold.

A rating of *Reserve Capacity* shows how many minutes the battery can power the vehicle's electrical system at 80°F with a current of 25 amps. This is useful if the changing system fails and the battery must keep the vehicle running until the charging system can be fixed.

Both Cold Cranking Amps and Reserve Capacity are useful ratings, but CCA is the most used and most important because most battery problems are associated with starting the vehicle, not running it with an inoperative charging system.

- **Choosing a New Battery**

If you are sure the old battery has been damaged or cannot be charged, you have to choose a new battery. You should install a new battery which is at least as large as the factory specifications, and preferably 20% larger. If the original battery was rated at 450 CCA, you should install one with 550 CCA.

Remember, a battery needs to have enough power to turn the engine, even at low temperatures. Larger engines need more current to turn them than small engines do.

Figure 2 shows that because batteries are weaker at low temperatures, engines require more battery power to start at low temperatures. Be sure to choose a large enough battery. You cannot harm the engine by using too large a battery, but you can cause starting problems if you choose one that is too small.

If you cannot be sure about the original battery specifications, as a general rule, select a battery with at least 350 CCA for engines smaller than 300 CID (5 liter), and at least 450 CCA for larger engines.

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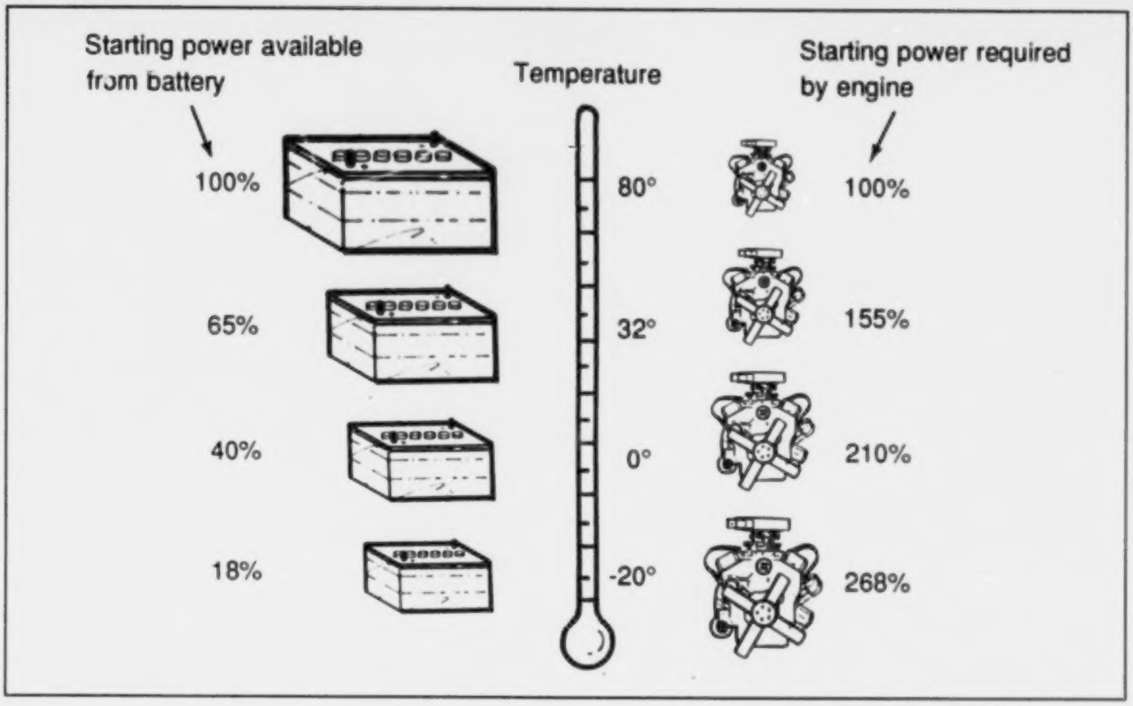
FIGURE 2


Starting power available from battery
Temperature
Starting power required by engine
100%
80°
100%
65%
32°
155%
40%
0°
210%
18%
-20°
268%

Batteries can have either post-type terminals or sealed-type terminals. The terminals can be located either on the top or on the side, depending on how the battery fits into the vehicle. When you choose a new battery for a vehicle, make sure the terminals are in the same places on the new battery as they are on the original.

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Estimated Battery Drain of Vehicle Optional Equipment

Air conditioner compressor, clutch, and high blower	19.0 amps
Air conditioner compressor, clutch, and low blower	7.5 amps
Digital clock	4.0 amps
Electric windows	12.0 amps
Engine computer	7.0 amps
Heater/high blower	16.0 amps
Heater/low blower	4.5 amps
Intermittent wipers	0.6 amps
Rear window defogger	21.0 amps

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Starting System Diagnosis Chart

To use this chart, turn the vehicle lights on and crank the engine. Notice what happens and decide on the possible solution.

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine cranks slowly, doesn't start	Discharged battery	Charge; test and replace if necessary.
	Very low temperature	Allow battery to warm up, check circuits and battery.
	Battery cables too small	Install correct battery cables.
	Defective starter motor	Test; repair or replace as needed.
	Engine malfunction	Check engine for low oil, mechanical. problems.
Solenoid clicks, chatters	Loose or corroded battery terminals	Remove, clean, reinstall.
	Battery discharged	Charge; test and replace if necessary.
	Wiring problem inside solenoid	Replace solenoid.
Lights stay bright, vehicle doesn't crank	High resistance at battery connection	Clean and tighten terminal connections.
	Open circuit in starter	Disassemble and repair or replace starter.
	Open circuit or high resistance in circuit	Check solenoid and relays; repair or replace if needed.
	Open circuit in safety switch	Check; repair or replace switch.

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Starting System Diagnosis Chart (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Lights dim greatly, vehicle doesn't crank	Discharged or malfunctioning battery	Charge and test battery; replace if necessary.
	Loose or corroded battery terminals	Remove, clean, reinstall.
	Very low temperature	Allow battery to warm up; check circuits and battery.
	Pinion not engaging ring gear	Check for damaged parts, alignment of starter.
	Solenoid engaged but not cranking	Check starter motor and connections.
	Pinion jammed—starter and flywheel out of alignment	Check pinion and gear teeth.
	Stuck armature in starter	Replace or repair starter.
	Short in starter	Replace or repair starter.
	Engine malfunction	Check engine for low oil, mechanical problems.
	High resistance in starter	Disassemble and repair or replace starter.
Lights out, vehicle doesn't crank	Poor connection (probably at battery or ground)	Clean cable clamp and terminal; tighten clamp.
	Open circuit	Clean and tighten connections, replace wiring if necessary.
	Discharged or malfunctioning battery	Charge and test battery; replace if necessary.
Whine or siren sound just after starting	Overrunning clutch defective	Repair or replace as needed.
	Solenoid plunger sticking	Repair or replace solenoid.

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Starting System Diagnosis Chart (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Whine or siren sound just after starting (Cont.)	Weak return spring	Replace spring.
	Damaged flywheel ring gear teeth	Remove and replace.
	Pinion jammed, too tight–starter and flywheel out of alignment	Check pinion alignment with gear teeth; shim if necessary.
Starter turns, engine does not	Pinion not engaging–starter and flywheel out of alignment	Check pinion alignment with gear teeth; shim if necessary.
	Pinion slipping	Replace or repair starter.
	Damaged flywheel ring gear teeth	Remove and replace.
Pinion disengages slowly when engine starts	Solenoid plunger sticking	Repair or replace solenoid.
	Overrunning clutch defective	Repair or replace as needed.
	Weak return spring	Replace spring.
	Pinion jammed, too tight–starter and flywheel out of alignment	Check pinion alignment with gear teeth; shim if necessary.

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Charging System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Faulty operation of lighting and electrical options (Undercharge)	Loose wiring connections	Inspect and repair wiring.
	High resistance in circuit	Test circuit, repair alternator.
	Defective regulator	Test and repair or replace regulator.
Low or no voltage (No-charge)	Defective drive belt	Adjust or replace belt.
	Dirty or loose battery cables	Clean, tighten, or replace cables.
	Defective battery	Test and charge or replace.
	Incorrect battery	Replace with correct battery.
	Faulty system wiring	Repair wiring.
	Faulty alternator	Repair or replace.
	Defective regulator	Repair or replace.
High voltage (Overcharge)	Faulty regulator	Replace or adjust regulator.
	Defective battery	Remove and replace.
	Faulty ground at regulator	Repair regulator ground.
	Defective regulator	Repair or replace.

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LAP SHEET

SERVICING ENGINE COOLING SYSTEMS

3

Name _______________________________

Check the blank as you complete each step.

1. **Take** _____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

2. **Read** _____ the introduction, unit objective, and specific objectives.

3. **Do** _____ the focus assignments.

4. **Stop** _____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.

5. **Study** _____ the Information Sheet, objective 1.

6. **Ask** _____ your instructor to explain the importance of the safety rules listed in objective 1.

Optional: Write _____ a short paragraph about the importance of following the safety rules that are applicable to this unit.

7. **Study** _____ the Information Sheet, objective 2.

8. **Ask** _____ your instructor to explain how the cooling system operates.

9. **Ask** _____ your instructor to explain the two types of liquid cooling systems and how each operates.

10. **Study** _____ the Information Sheet, objective 3.

11. **Ask** _____ your instructor to explain the function of each part of the cooling system shown in Figure 1.

Optional: Examine _____ A display of cooling system components outside a vehicle.

12. **Study** _____ the Information Sheet, objective 4.

13. **Ask** _____ your instructor to explain the safety hazards and precautions to be followed when removing a radiator cap.

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Optional: Label ____ the parts of the radiator cap on a picture of a radiator cap available from your instructor. Check your labeling by referring to Figure 3.

14. **Study** ____ the Information Sheet, objective 5.

15. **Ask** ____ your instructor to explain the functions of the parts of a radiator cap shown in Figure 3.

16. **Ask** ____ your instructor to explain the role the radiator cap plays in making the cooling system function properly.

17. **Ask** ____ your instructor to explain how pressure affects the boiling point of coolant.

18. **Study** ____ the introduction to Job Sheet 1.

19. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

20. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

21. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

22. **Study** ____ the introduction to Job Sheet 2.

23. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

24. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

25. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

26. **Study** ____ the introduction to Job Sheet 3.

27. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

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28.	**Practice**	____	the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.
29.	**Stop**	____	and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.
30.	**Study**	____	the Information Sheet, objective 10.
31.	**Ask**	____	your instructor to explain the operation and characteristics of the cooling system fans illustrated in Figures 4-8.
	Optional: Label	____	the types of fans on a sheet given to you by your instructor. Check them using Figures 4-8.
32.	**Study**	____	the introduction to Job Sheet 4.
33.	**Ask**	____	your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.
34.	**Practice**	____	the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.
35.	**Stop**	____	and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.
36.	**Ask**	____	your instructor for Handout 1, Troubleshooting the Cooling System, and Handout 2, Cooling System Diagnostic Chart.
37.	**Study**	____	Handout 1 and Handout 2.
38.	**Ask**	____	your instructor to review the information in Handout 1 and Handout 2 with you.
39.	**Do**	____	the Assignment Sheet, objective 12.
40.	**Stop**	____	and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.
41.	**Take**	____	the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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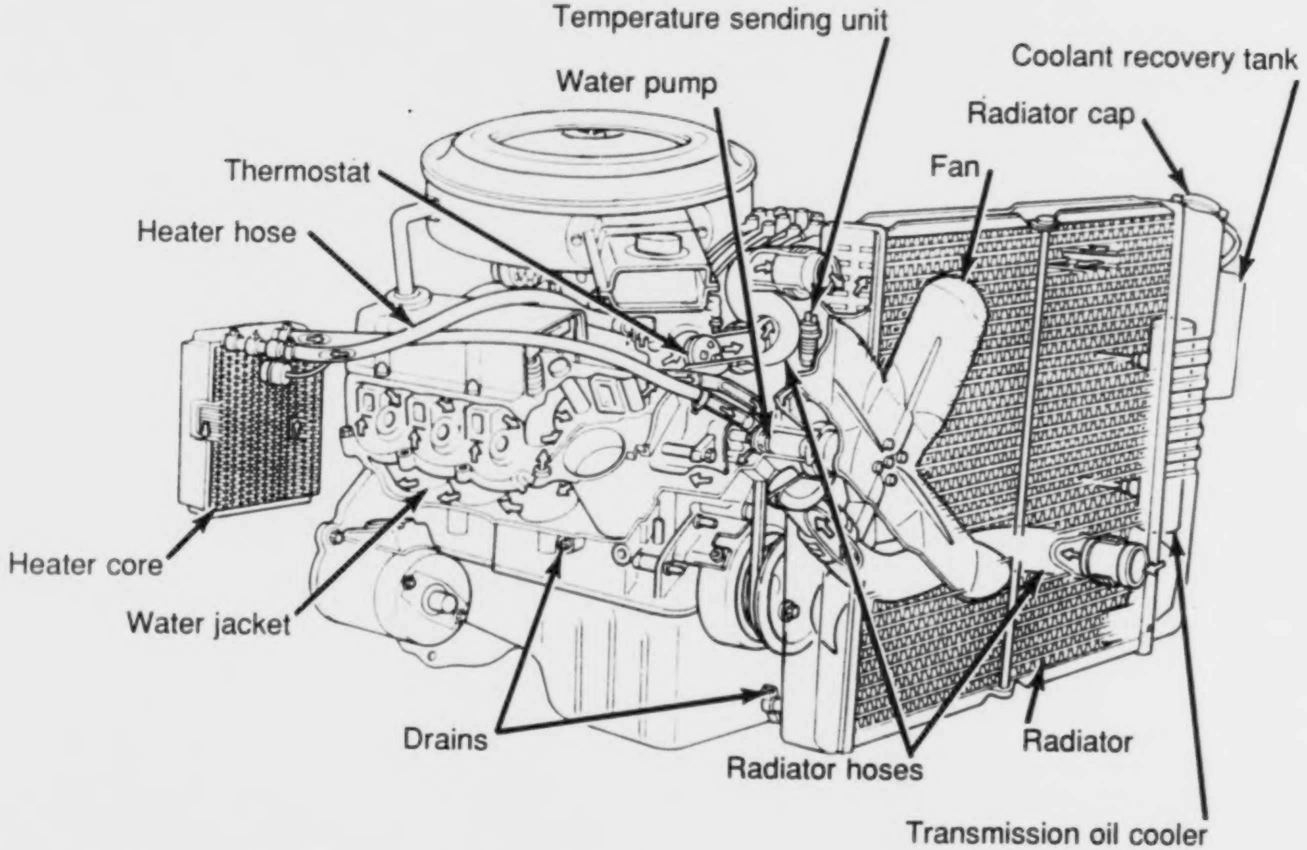
Engine
Cooling System Components


Temperature sending unit
Coolant recovery tank
Water pump
Radiator cap
Fan
Thermostat
Heater hose
Heater core
Water jacket
Drains
Radiator hoses
Radiator
Transmission oil cooler

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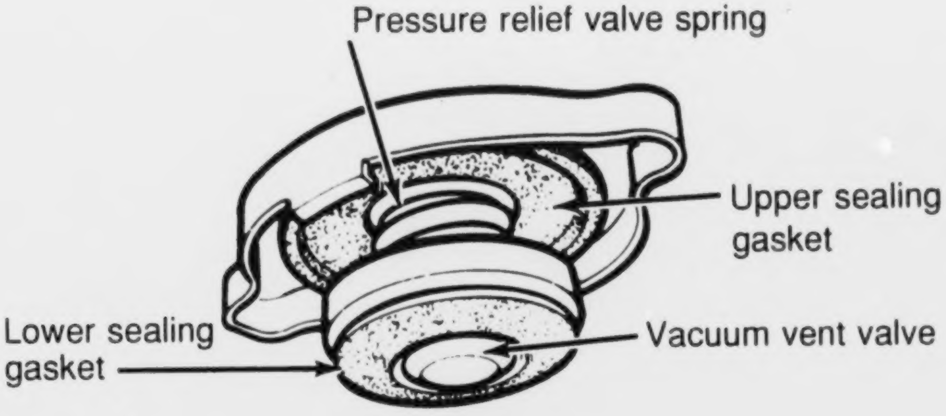
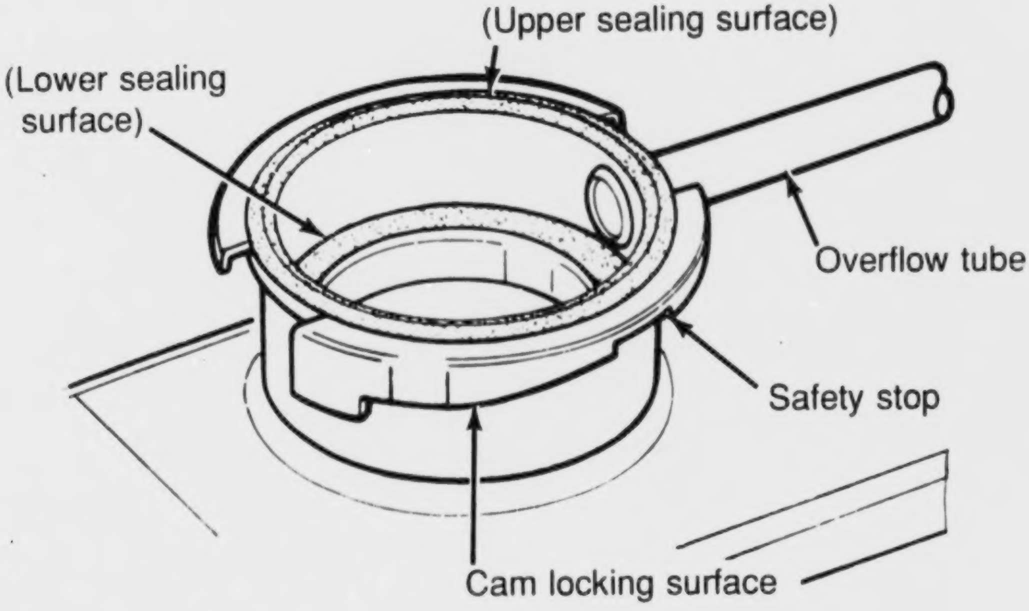
Radiator Cap Assembly


Pressure relief valve spring
Upper sealing gasket
Lower sealing gasket
Vacuum vent valve


(Upper sealing surface)
(Lower sealing surface)
Overflow tube
Safety stop
Cam locking surface

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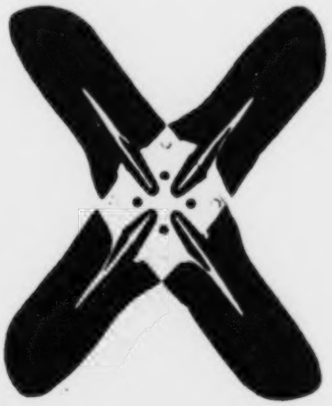
Cross Fan



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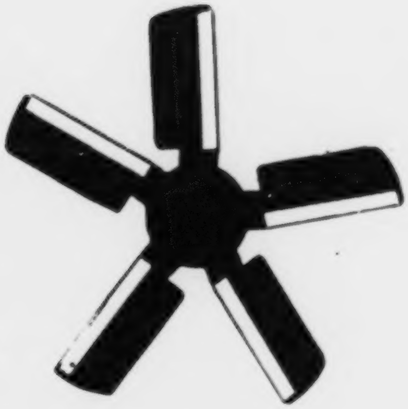
Power Flex Fan



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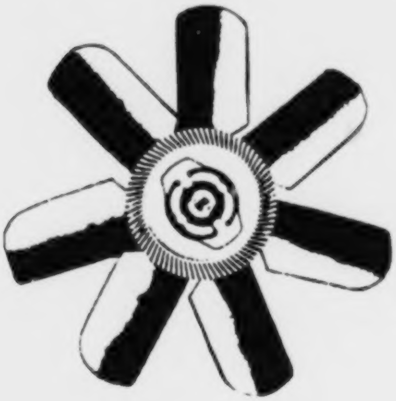
Thermo-Clutch Fan



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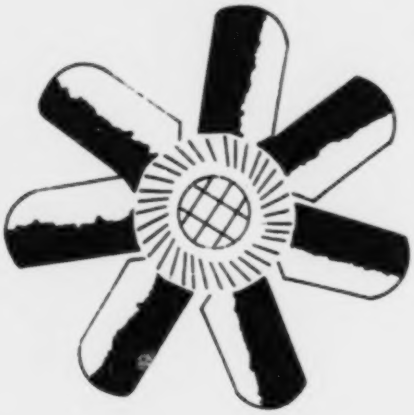
Viscous-Clutch Fan



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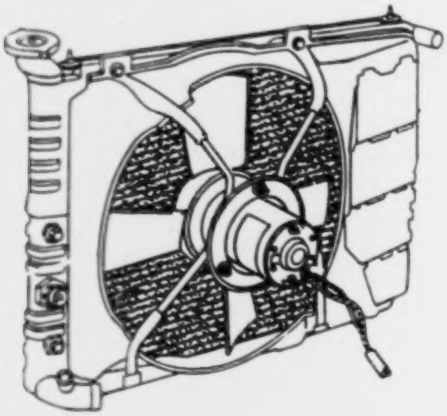
Electric Fan



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WRITTEN TEST

SERVICING ENGINE COOLING SYSTEMS

3

Name ______________________ Date __________ Score ____

OBJECTIVE 1

List safety rules for working with automotive cooling systems. Write each rule on the lines provided.

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____

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7. ____

____

____

8. ____

____

____

9. ____

____

____

10. ____

____

____

11. ____

____

____

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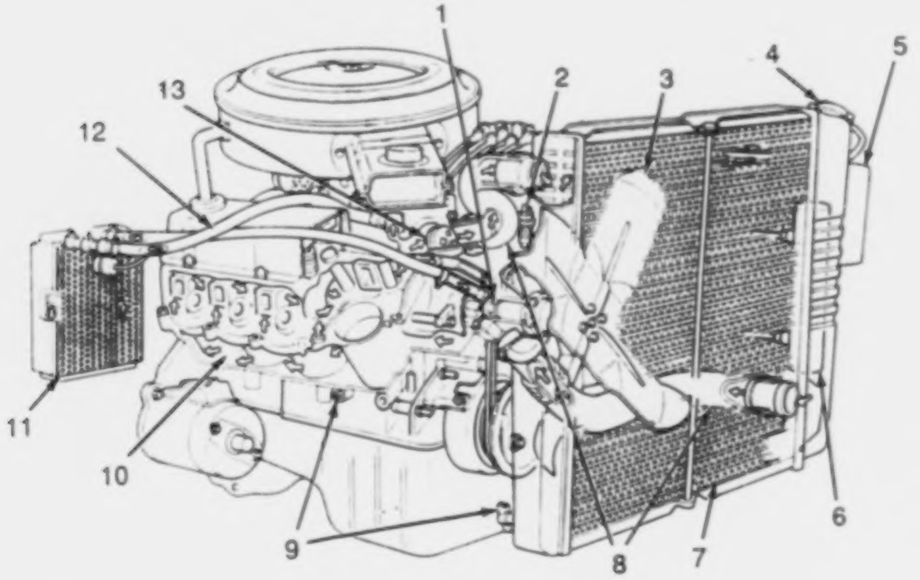
OBJECTIVE 2

Label the components of an engine cooling system indicated on an illustration. Write the name of each designated part in the corresponding blank following the illustration.



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1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

9. ______________________________

10. ______________________________

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11. ____________________

12. ____________________

13. ____________________

OBJECTIVE 3

Match the names of cooling system components to descriptions of their functions. Write the letter for each component in the blank before the description of its function.

A. air spoiler/dam
B. coolant
C. coolant recovery tank
D. drains
E. fan
F. heater core
G. heater hoses
H. radiator
I. radiator cap
J. radiator hoses
K. temperature sending unit
L. thermostat
M. transmission oil cooler
N. water jacket
O. water pump

____ 1. Provide a way to remove coolant from the radiator and engine block

____ 2. Pulls air through the radiator core to dissipate the heat being carried by the coolant to the radiator

____ 3. Provides heat for the passenger compartment heating system

____ 4. Controls the flow of coolant to maintain the correct engine operating temperature

____ 5. Forces coolant through the engine and other cooling system components

____ 6. Circulates through the cooling system to carry heat away from the engine to the radiator for transfer to the outside air

____ 7. Allows heat from the coolant to be transferred to the outside air

____ 8. Maintains the correct pressure in the cooling system

____ 9. Carry coolant to and from the radiator to the engine

____ 10. Cools the automatic transmission fluid

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_____ 11. Minimizes the loss of coolant by catching coolant overflow when the system pressure increases during operation

_____ 12. Contains and directs the flow of coolant through the inside of the engine block

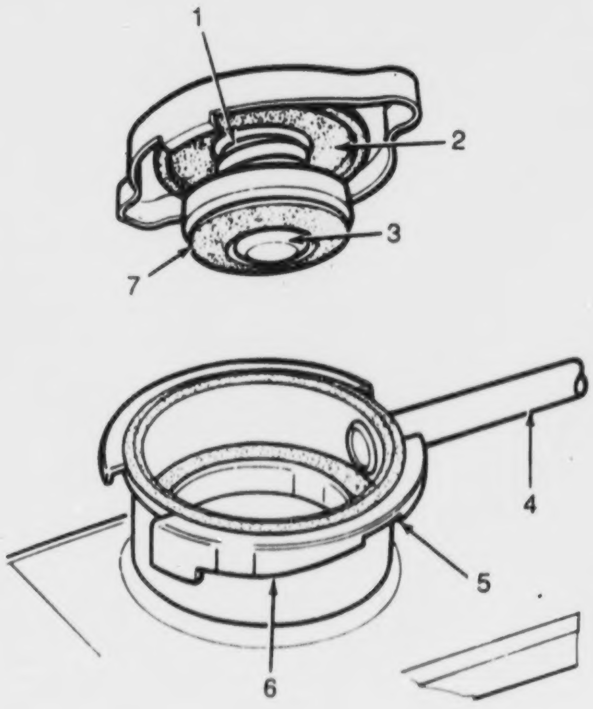
_____ 13. Provides a signal that indicates the temperature condition in the cooling system

_____ 14. Carry coolant to and from the heater core and the cooling system

_____ 15. Directs air flow to assist in cooling the engine and reduces the amount of air turbulence and drag under the vehicle

OBJECTIVE 4

Label the parts of a radiator cap assembly indicated on an illustration. Write the name of each designated part in the corresponding blank following the illustration.



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1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________

OBJECTIVE 5

Match the names of the parts of a radiator cap assembly to descriptions of their functions. Write the letter for each part in the blank before the description of its function.

A. cam locking surface
B. lower sealing gasket
C. overflow tube
D. pressure relief valve spring
E. safety stop
F. upper sealing gasket
G. vacuum vent valve

____ 1. Carries coolant to and from the radiator and the coolant recovery tank

____ 2. Protects the radiator from collapsing from the vacuum produced when the system cools down

____ 3. Locks the radiator cap into position on the radiator neck, ensuring a good tight seal between the two

____ 4. Exerts internal pressure to seal the cooling system

____ 5. Creates a seal between the radiator cap and the lower sealing surface

____ 6. Provides a pressure seal between the radiator cap and the upper sealing surface of the radiator neck

____ 7. Prevents the radiator cap from being removed before the pressure within the system is relieved

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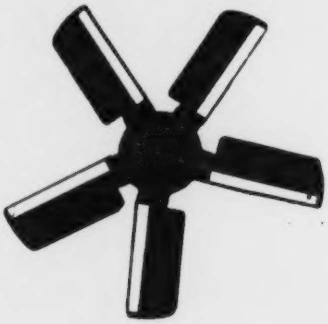
OBJECTIVE 6 **Evaluated on Job Sheet 1.**

OBJECTIVE 7 **Evaluated on Job Sheet 2.**

OBJECTIVE 8 **Evaluated on Job Sheet 3.**

OBJECTIVE 9 **Name types of cooling system fans shown in illustrations.**
Write the type of fan shown in the blank below each illustration.



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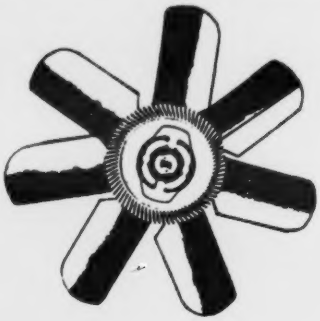
1. Type of fan: ______________________



2. Type of fan: ______________________

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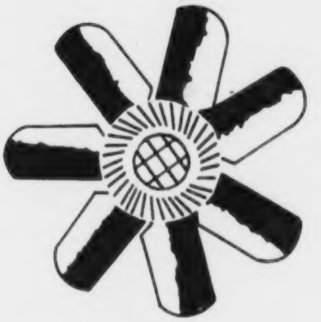

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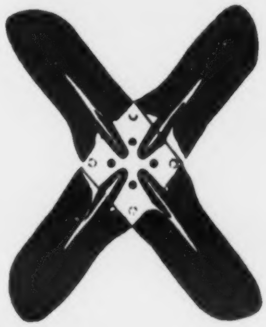
3. Type of fan: ______________________________



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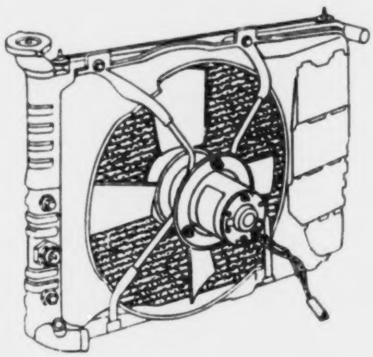
4. Type of fan: ______________________________



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5. Type of fan: ______________________________

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OBJECTIVE 10 **Match the names of types of cooling system fans to descriptions of their operation.** Match the names of the fans to the descriptions of their operation.

A. cross fan
B. electric fan
C. power flex fan
D. thermo-clutch fan
E. viscous-clutch fan

_____ 1. Controlled by a bimetal coil spring which engages the fan only when engine temperatures are high

_____ 2. Belt-driven and turns at all times when the engine is operating

_____ 3. Operated by a heat-sensitive switch or sensor that turns it on and off

_____ 4. Flexible blades bend at low speeds to draw maximum air flow through the radiator core and flatten at high speeds to save power and decrease noise.

_____ 5. Its silicone oil thickens and engages the fan only when the engine is hot.

OBJECTIVE 11 **Evaluated on Job Sheet 4.**

OBJECTIVE 12 **Evaluated on the Assignment Sheet.**

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Troubleshooting The Cooling System

As an Engine Performance Technician, you must be able to locate and correct cooling system problems quickly and accurately. Cooling system problems can be categorized as:

Coolant leaks — Coolant leaks are the result of cracks, ruptures, or faulty radiator caps that allow coolant to escape from the system.

Overheating — Overheating occurs when the engine's operating temperature is too high. The signs of overheating are warning light on, temperature gauge showing high temperature, and/or coolant and steam blowing out the overflow. The engine may also knock or ping under a load.

Overcooling — Overcooling occurs when the engine fails to reach full operating temperature. The signs are poor fuel economy and possibly poor or sluggish engine performance.

Use the following steps to assist you in diagnosing cooling system problems.

1. Talk to the vehicle's owner. The first step in diagnosing any automotive problem is to talk to the vehicle's owner about the nature of the problem and the service history of the vehicle. You might ask such questions as:

    - When was the last time the coolant was replaced?
    - Have any repairs (new thermostat, hoses, or engine repairs) been made recently?
    - Have you noticed any coolant leaks (puddles on the ground, wetness around the engine) or have you added coolant?

    ☑ **NOTE:** The answers to these questions will help you eliminate the least likely sources of problems so you can concentrate on the most probable causes.

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2. Consult the service manual troubleshooting guide. Check for the problem you suspect in the service manual for the vehicle you are evaluating *before you take it on the road.* See what type of road tests you should make on the vehicle and what symptoms to look for. Know beforehand what you will need to do and observe.

3. Road test the vehicle to verify the problem. Make sure the coolant level is correct before you start. Drive in a quiet area and try to reproduce the problems and noises described to you by the owner.

   ☑ **NOTE:** The purpose of the road test is to verify the problems and to try to determine the exact nature of the problem or where the noise is coming from. Use Handout 2, Cooling System Diagnosis Chart, to help identify common problems.

4. Make an inspection. Examine the cooling system, and look for obvious problems:

   - Coolant leaks — Leaks can occur almost anywhere in the system, so check hoses, radiator clamps, water pump, thermostat housing, radiator drain, and core plugs in the block, heater hoses, and heater core. The leaking fluid will smell like antifreeze, a sweet odor. Leaks show up as wet, discolored (may be darkened or rust colored, but usually green) areas in the engine compartment or on the ground.

   - Loose or missing fan belts

   - Low coolant level — A low coolant level may indicate a leak. If the leak is not visible, then it may be an internal leak caused by a cracked engine part, a damaged head gasket, etc.

   - Abnormal water pump noises

   - Leaves, bugs, or debris covering the outside of the radiator

5. Note your results. As you make your checks, write down a few notes about your observations.

6. Make a preliminary diagnosis. Consider all the information you have gathered, and make an initial diagnosis of the vehicle's problems.

7. Check your diagnosis. You may need to check your diagnosis by making additional tests as outlined below. Always make the simpler, less time-consuming tests first.

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8. Pressure test the system. If a visual inspection does not reveal the cause of the coolant loss, pressure test the system. If the pressure drops on the gauge, there is an internal or external leak. Repeat the visual inspection. With the system under pressure, it is quite possible the source of the leak can be seen.

9. Check the radiator cap. If the radiator cap fails to hold the specified pressure, the coolant can boil off or leak. Check the radiator cap with the same tester used to check the system.

10. Consider internal leaks. Coolant may also be lost inside the engine because of a faulty cylinder head gasket or a cracked cylinder head or block. When this occurs, coolant may end up in the crankcase. Pull the dipstick and check for coolant in the oil. When water, antifreeze, and oil mix, the solution turns milky white. Check for exhaust leaks in the cooling system from a defective head gasket. A combustion leak test checks for the presence of exhaust gases in the engine coolant. It should be performed when indications (such as overheating, bubbles in coolant, or a rise in coolant level which occurs upon starting) point to a damaged head gasket, cracked block, or cracked cylinder head.

11. Consider poor coolant flow, poor air flow, or poor heat flow. If there is no loss of coolant from the system, overheating may be due to poor coolant flow, poor air flow, or poor heat flow.

    - Poor coolant flow may be caused by a defective fan belt, stuck thermostat, retarded ignition timing, defective water pump, or ice in the coolant. A restriction in the radiator may slow coolant flow, resulting in overheating. Restrictions may be caused by rust, scale, or a collapsed lower radiator hose.

    - Poor air flow through the radiator core can cause overheating. A slipping fan belt, malfunctioning fan clutch, electric fan problems, or missing fan shroud can prevent air from moving through the radiator core at low vehicle speeds. A missing air spoiler/dam can also contribute to poor air flow. Radiator fins clogged with bugs, paper, or other debris can reduce air flow.

    - Poor heat flow may result from too much corrosion and scale build-up in the cylinder block and cylinder head water jackets. The heat developed in the cylinders and combustion chambers cannot flow properly through the barrier of corrosion and scale. This condition may be suspected if all of the other troubleshooting procedures fail to reveal the problem.

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12. Check for overcooling. Overcooling may be caused by a thermostat stuck open, a locked fan clutch, or a shorted fan switch.

13. Diagnose and repair or replace the cooling system components. Once you have made your diagnosis, use the vehicle's service manual and the Job Sheets in this unit to help you remove and disassemble the component involved. Your inspection and repair during this step should confirm and correct the problem(s). A final test drive should always be made to ensure the problem has been corrected.

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Cooling System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Low coolant level	External leakage	Inspect hoses, hose connections, radiators, edges of cooling system gaskets, core (freeze) plugs and drain plugs, transmission oil cooler lines, water pump, and heater system components. Service or replace as required.
	Pressure cap and cap gasket leaks	Inspect, wash gasket, and test. Replace only if cap will not hold pressure test specifications.
	Radiator filler neck leak	Inspect radiator filler neck sealing surface for damage or foreign material. Repair or replace as needed.
	Undetermined leakage	Pressure test system.
	Internal leakage (into the engine)	Check engine oil and transmission oil dipsticks for signs of coolant. Check coolant for signs of transmission oil. Check torque on headbolts, tighten if necessary. Disassemble engine as necessary. Check for cracked intake manifold, damaged head gasket, leaks at water crossover intake manifold gasket, warped head or block gasket surfaces, cracked cylinder head or block gasket surfaces, or engine block.
Engine overheating	Low coolant level	Check for coolant loss. Fill as required.
	Damaged head gasket	Replace gasket.

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Cooling System Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine overheating (Continued)	Radiator or A/C condenser obstruction	Remove bugs, leaves, etc. Clean out air passages thoroughly by using air pressure from engine side of radiator.
	Loose fan belt	Adjust and/or replace.
	Excessive rust and sludge in coolant	Flush system, refill with new coolant.
	Defective radiator cap	Test. Replace if necessary.
	Closed thermostat	Test. Replace if necessary.
	Defective fan drive clutch	Test. Replace if necessary.
	Retarded ignition timing	Check timing and advance. Adjust as required.
	Inoperative water pump	Replace pump.
	False temperature gauge or cold light readings	Check electrical circuits and service as required. Refer to appropriate service manual.
	Water jacket passages clogged	Clean engine block passages.
	Restricted radiator	Remove radiator and have it rodded.
	Exhaust system	Check for restrictions.
Poor coolant flow	Restricted radiator	Remove and clean.
	Inoperative thermostat	Test. Replace if necessary.
	Restriction in system	Check hoses for crimps.
	Excessive rust or sludge	Clear the system of rust and sludge by flushing radiator.
	Insufficient coolant	Replenish.
	Loose fan belt	Adjust.
	Inoperative water pump	Replace.
Poor air flow	Loose fan belt	Adjust.
	Malfunctioning fan clutch	Test. Replace if necessary.

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Cooling System Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Poor air flow (Continued)	Electric fan problems	Check electrical circuits and service as required. Refer to appropriate service manual.
	Missing fan shroud	Replace.
	Missing air dam/spoiler	Replace.
	Radiator fins clogged with bugs, debris, etc.	Clean.
Poor heat flow	Excessive impurities in the water used with the coolant	Replace with soft, clean water.
	Infrequent flushing and draining of the system	Drain and flush the system. Refill with a permanent antifreeze mixture (ethylene glycol base).
Overcooling	Open thermostat	Test. Replace if necessary.
	Inaccurate temperature gauge (false readings)	Replace.
Noise	Squeak at water pump mechanical seal	Replace pump assembly.
	Damaged or worn water pump bearing	Replace pump assembly.

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LAP
SHEET

SERVICING EXHAUST SYSTEMS

4

Name ____

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read** ____ the introduction, unit objective, and specific objectives.
3. **Do** ____ the focus assignments.
4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study** ____ the Information Sheet, objective 1.
6. **Ask** ____ your instructor to show you parts the of an exhaust system on an actual vehicle.
7. **Study** ____ the Information Sheet, objective 2.
8. **Ask** ____ your instructor to explain the function of each component of the exhaust system shown in Figure 1.
9. **Study** ____ the introduction to Job Sheet 1.
10. **Ask** ____ your instructor to explain what exhaust problems may cause low backpressure.
11. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.
12. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

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13. **Stop** ____ and have your instructor evaluate your work. After your work has been evaluated, follow your instructor's recommendations.
14. **Study** ____ the introduction to Job Sheet 2.
15. **Ask** ____ your instructor to explain the relationship of exhaust system components.
16. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.
17. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.
18. **Stop** ____ and have your instructor evaluate your work. After your work has been evaluated, follow your instructor's recommendations.
19. **Study** ____ the introduction to Job Sheet 3.
20. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.
21. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.
22. **Stop** ____ and have your instructor evaluate your work. After your work has been evaluated, follow your instructor's recommendations.
23. **Study** ____ the Information Sheet, objective 6.
24. **Ask** ____ your instructor to explain the operation of a catalytic converter.
25. **Study** ____ the Information Sheet, objective 7.
26. **Ask** ____ your instructor to explain the differences between the types of catalytic converters shown in Figures 5 and 6.

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27. **Study** ____ the Information Sheet, objective 8.

28. **Ask** ____ your instructor to explain the operation of the five versions of catalytic converters.

29. **Study** ____ the introduction to Job Sheet 4.

30. **Ask** ____ your instructor to explain why the catalytic converter must be in good condition for the exhaust system to perform correctly.

31. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

32. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

33. **Stop** ____ and have your instructor evaluate your work. After your work has been evaluated, follow your instructor's recommendations.

34. **Take** ____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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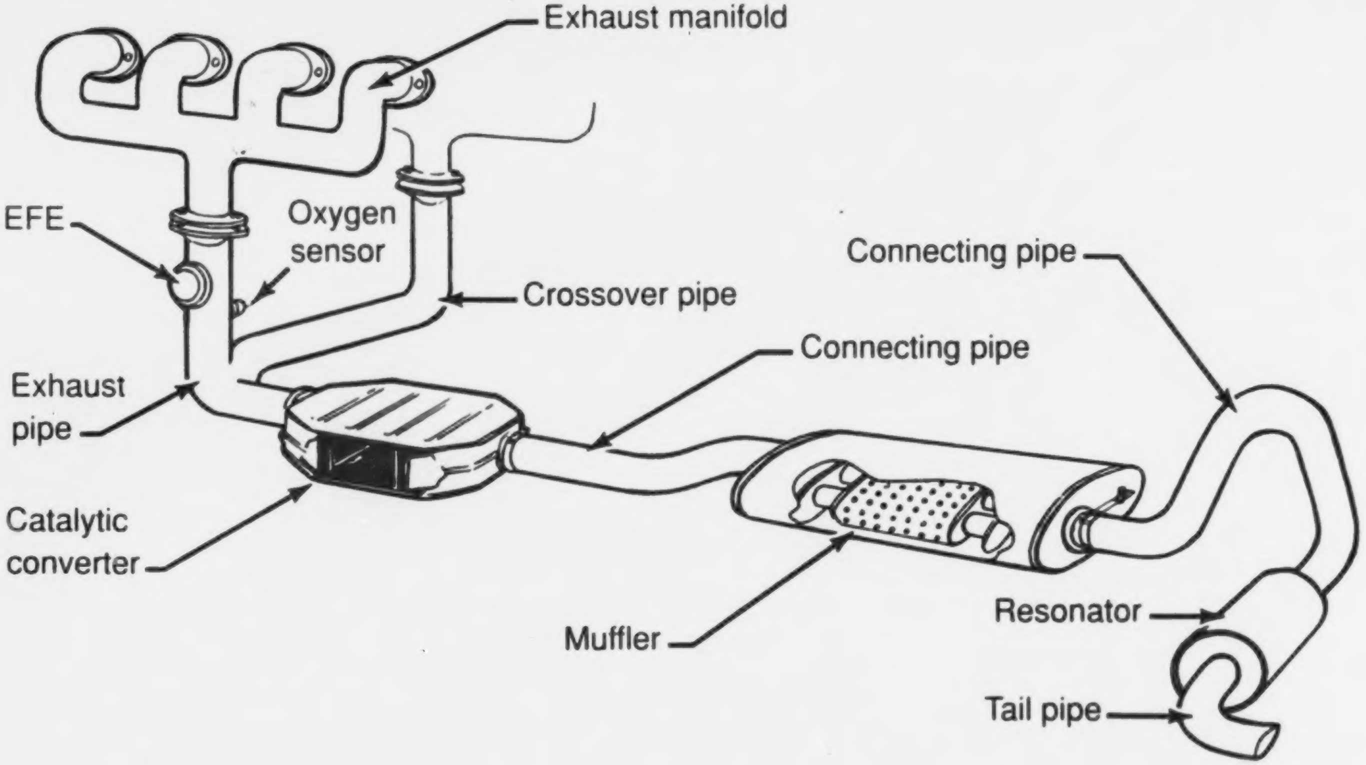
Exhaust System


Exhaust manifold
EFE
Oxygen sensor
Crossover pipe
Connecting pipe
Connecting pipe
Exhaust pipe
Catalytic converter
Muffler
Resonator
Tail pipe

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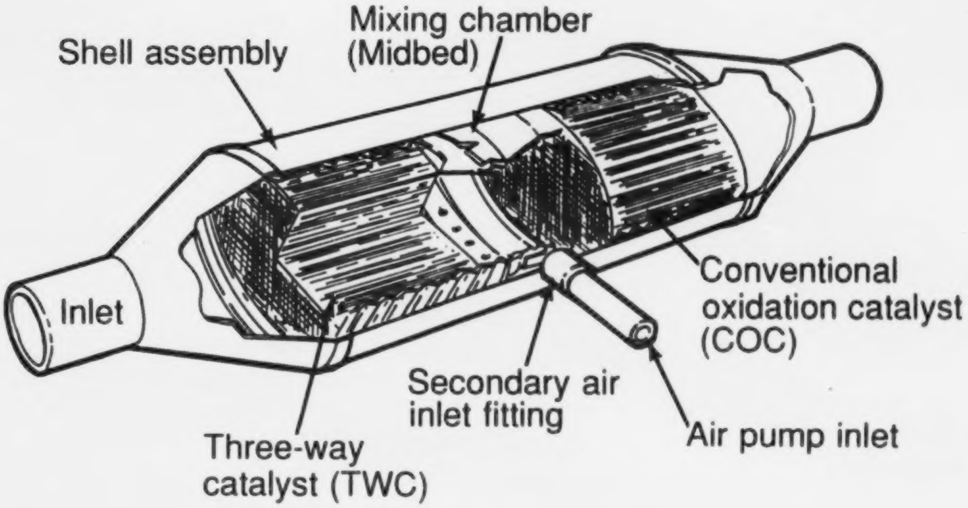
INSTRUCTOR'S RESOURCE PACKAGE : Engine Performance Specialist
TRANSPARENCY MASTER 1 - **CIMC** · 4 · 1

TM 1

Honeycomb Type Catalytic Converter


Shell assembly
Mixing chamber (Midbed)
Conventional oxidation catalyst (COC)
Inlet
Secondary air inlet fitting
Air pump inlet
Three-way catalyst (TWC)

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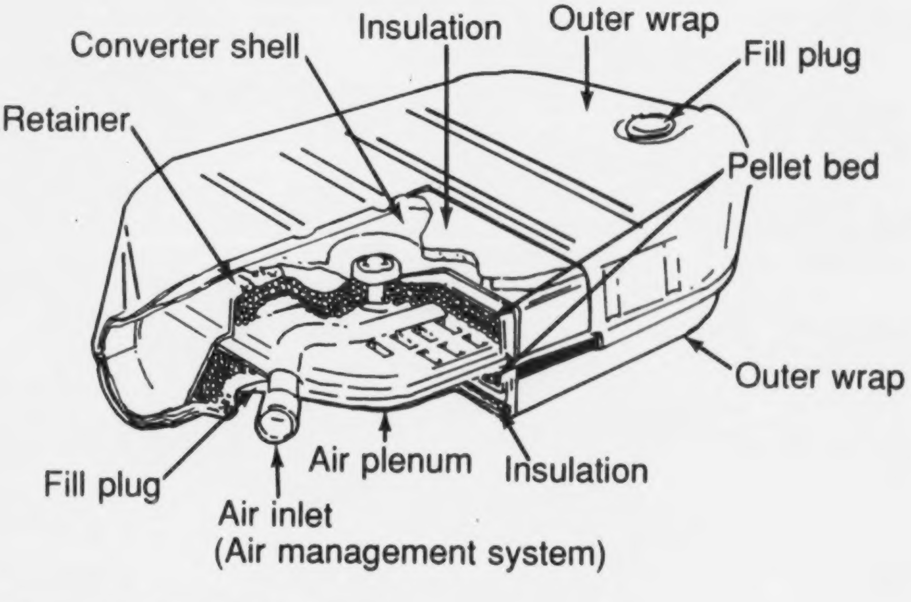
Pellet Type Catalytic Converter


Converter shell
Insulation
Outer wrap
Fill plug
Retainer
Pellet bed
Outer wrap
Fill plug
Air plenum
Insulation
Air inlet (Air management system)

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WRITTEN TEST

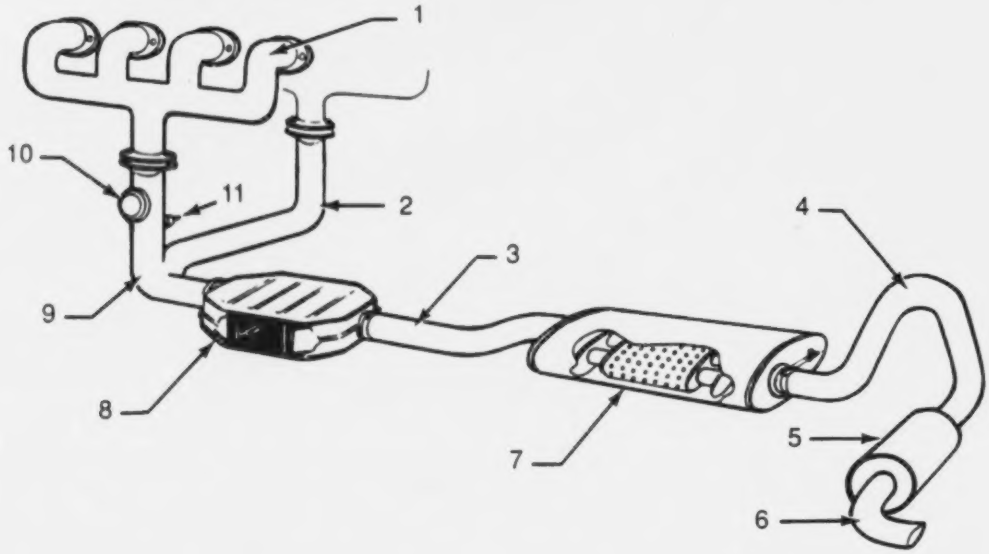
SERVICING EXHAUST SYSTEMS

4

Name ______________________________ Date _________ Score ____

OBJECTIVE 1

Label the parts of an exhaust system indicated on an illustration. Write the name of each part in the corresponding numbered blank.



1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

May be photocopied for student use.

9. ______________________________

10. ______________________________

11. ______________________________

OBJECTIVE 2

Match the names of exhaust system components to descriptions of their functions. Write the letter of the answer in the blank beside the correct description.

A. catalytic converter
B. connecting pipe
C. crossover pipe
D. early fuel evaporation (EFE) system
E. exhaust manifold
F. exhaust pipe
G. muffler
H. oxygen sensor
I. resonator
J. tail pipe

_____ 1. Reduces noise produced by pulsating exhaust gases

_____ 2. Chemically changes harmful combustion gases into harmless byproducts

_____ 3. The end of the exhaust system from which gases pass to the outside air

_____ 4. Collects waste gases from each engine cylinder and directs them away from cylinder head exhaust ports

_____ 5. Measures the amount of oxygen in the exhaust gas

_____ 6. Joins exhaust system components downstream from the catalytic converter

_____ 7. A small additional muffler sometimes added to absorb remaining exhaust sounds

_____ 8. Heats the air and fuel entering the intake manifold to help start a cold engine

_____ 9. Connects both sides of the manifold on a V-type engine to allow them to share a common exhaust system

_____ 10. Directs exhaust gases from the exhaust manifold to the catalytic converter

OBJECTIVE 3

Evaluated on Job Sheet 1.

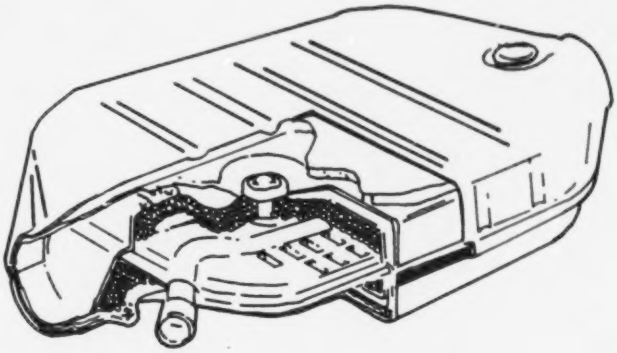
May be photocopied for student use.

OBJECTIVE 4 **Evaluated on Job Sheet 2.**

OBJECTIVE 5 **Evaluated on Job Sheet 3.**

OBJECTIVE 6 **Describe the operation of a catalytic converter.** Write your description in the space provided.

OBJECTIVE 7 **Name types of catalytic converters shown in illustrations.** Write the type of catalytic converter shown in the blank.



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1. Type of catalytic converter: ______________________
   (Use figure above.)

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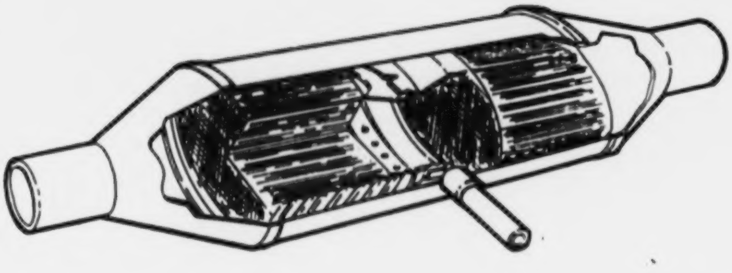

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2. Type of catalytic converter: ______________________________
   (Use figure above.)

OBJECTIVE 8

Match the names of versions of catalytic converters to descriptions of their operation. Write the letter of the answer in the blank beside the correct description.

A. dual-bed
B. minicatalytic
C. single-bed
D. three-way
E. two-way

_____ 1. Oxidizes hydrocarbons and carbon monoxide and also reduces damaging oxides of nitrogen, changing them to nitrogen and oxygen

_____ 2. Oxidizes harmful hydrocarbons and carbon monoxide, changing them into relatively harmless carbon dioxide and water

_____ 3. Has two chambers which reduce the nitrogen and oxidize the hydrocarbons and carbon monoxide

_____ 4. A small honeycomb-type catalytic converter which may be built into or directly next to the exhaust manifold

_____ 5. Has all the catalytic materials in one chamber

OBJECTIVE 9

Evaluated on Job Sheet 4.

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LAP
SHEET

EVALUATING ENGINE CONDITION

5

Name ____

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read** ____ the introduction, unit objective, and specific objectives.
3. **Do** ____ the focus assignments.
4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study** ____ the Information Sheet, objectives 1 and 2.
6. **Ask** ____ your instructor to explain how valve train timing and ignition timing differ and how they are similar.
7. **Study** ____ the Information Sheet, objective 3.
8. **Ask** ____ your instructor to explain how improper valve train timing can affect emissions.
9. **Study** ____ the Information Sheet, objective 4.
10. **Ask** ____ your instructor to explain the differences between the two types of valve trains shown in Figures 1 and 2.
11. **Ask** ____ your instructor to show you an overhead valve train and an overhead cam valve train on actual vehicles.
12. **Study** ____ the Information Sheet, objective 5.
13. **Ask** ____ your instructor to describe the functions of the parts of the valve trains shown in Figures 1 and 2.

May be photocopied for student use.

14. **Study** ____ the Information Sheet, objective 6.

15. **Ask** ____ your instructor to explain the advantages and disadvantages of the three ways the camshaft can be driven.

16. **Study** ____ the introduction to Job Sheet 1.

17. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

18. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

19. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

20. **Study** ____ the introduction to Job Sheet 2.

21. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

22. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

23. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

24. **Study** ____ the introduction to Job Sheet 3.

25. **Ask** ____ your instructor to explain how to use Handout 1.

26. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

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27. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

28. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

29. **Study** ____ the introduction to Job Sheet 4.

30. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

31. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

32. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

33. **Study** ____ the introduction to Assignment Sheet 1.

34. **Do** ____ Assignment Sheet 1.

35. **Stop** ____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

36. **Study** ____ the Information Sheet, objective 12.

37. **Ask** ____ your instructor to explain high compression engines and why they may require high octane fuel.

38. **Study** ____ the Information Sheet, objectives 13-19.

39. **Ask** ____ your instructor to show you an older engine with normal wear and tear while pointing out the parts most frequently affected by normal engine wear and tear.

40. **Study** ____ the Information Sheet, objective 20.

41. **Study** ____ the introduction to Job Sheet 5.

May be photocopied for student use.

42. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 5. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

43. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

44. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

45. **Study** ____ the Information Sheet, objectives 22-23.

46. **Study** ____ the introduction to Assignment Sheet 2.

47. **Do** ____ Assignment Sheet 2.

48. **Stop** ____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

49. **Study** ____ introduction to Job Sheet 6.

50. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 6. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

51. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

52. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

53. **Study** ____ the introduction to Assignment Sheet 3.

54. **Do** ____ Assignment Sheet 3.

55. **Stop** ____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

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56. **Study** ____ the introduction to Job Sheet 7.

57. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 7. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

58. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

59. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

60. **Study** ____ the introduction to Job Sheet 8.

61. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 8. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

62. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

63. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

64. **Study** ____ the Information Sheet, objective 29.

65. **Study** ____ the Information Sheet, objectives 30-31.

66. **Ask** ____ your instructor to explain the information that can be obtained with the equipment shown in Figures 3-7.

67. **Examine** ____ the various examples of test equipment.

68. **Study** ____ the Information Sheet, objective 32.

69. **Study** ____ the introduction to Assignment Sheet 4.

70. **Do** ____ Assignment Sheet 4.

71. **Stop** ____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

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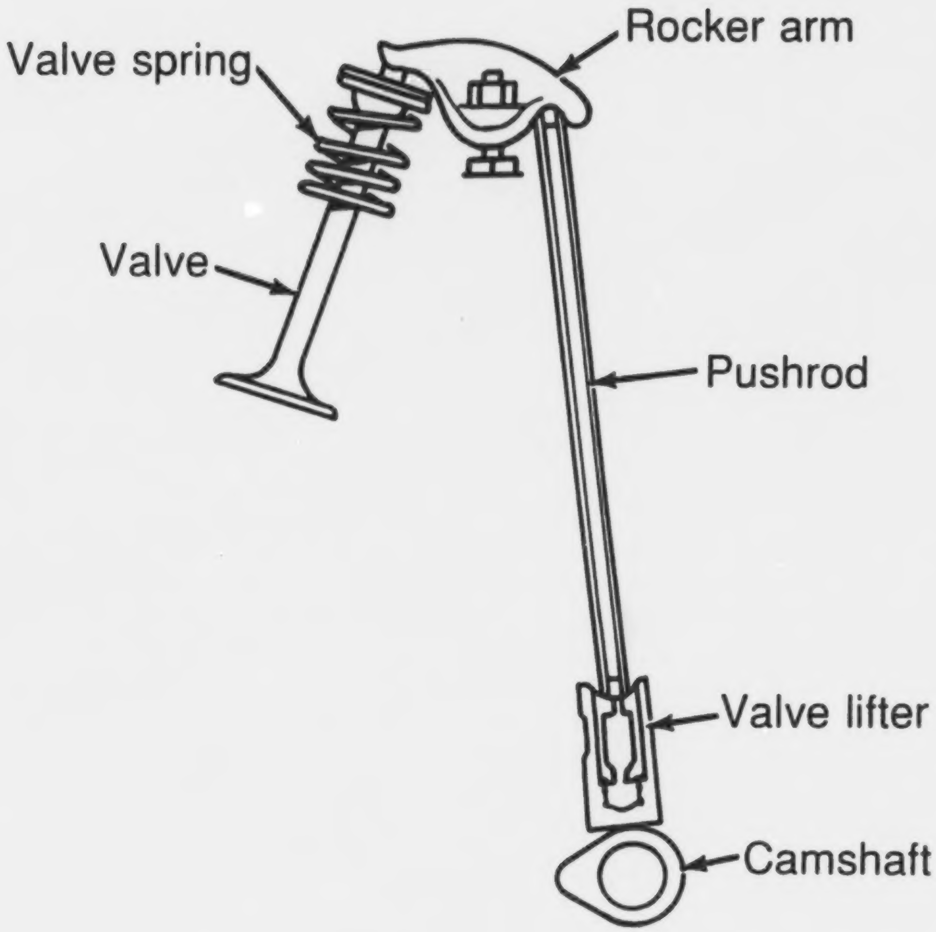
72. **Study** ____ the introduction to Assignment Sheet 5.

73. **Do** ____ Assignment Sheet 5.

74. **Stop** ____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

75. **Take** ____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

Overhead Valve


Rocker arm
Valve spring
Valve
Pushrod
Valve lifter
Camshaft

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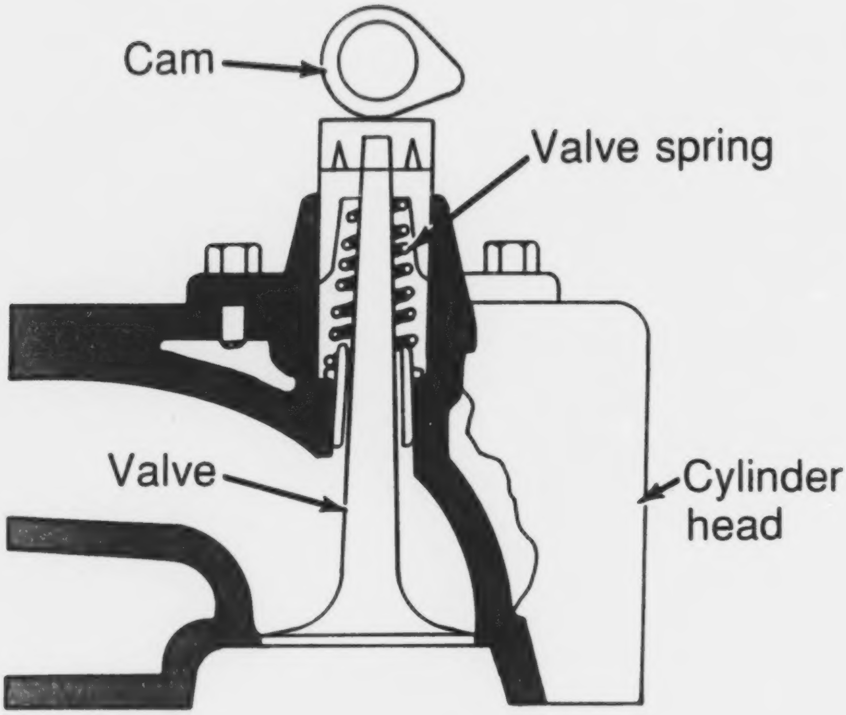
Overhead Cam


Cam
Valve spring
Valve
Cylinder head

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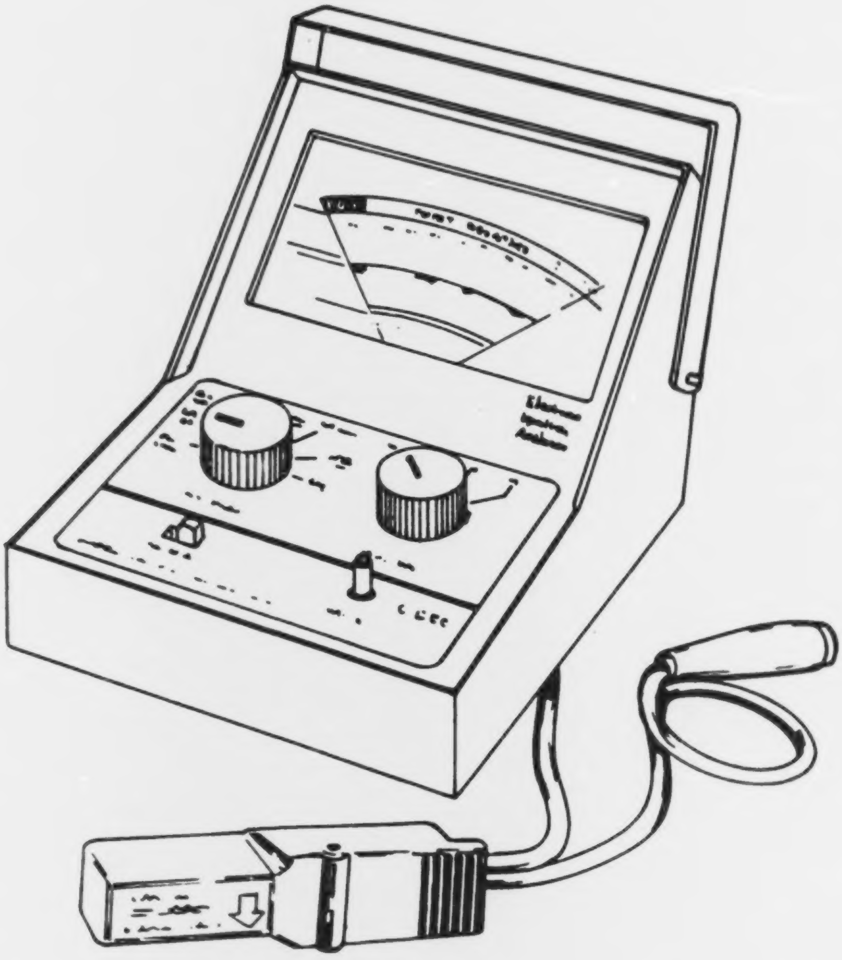
Tach-Dwell Meter



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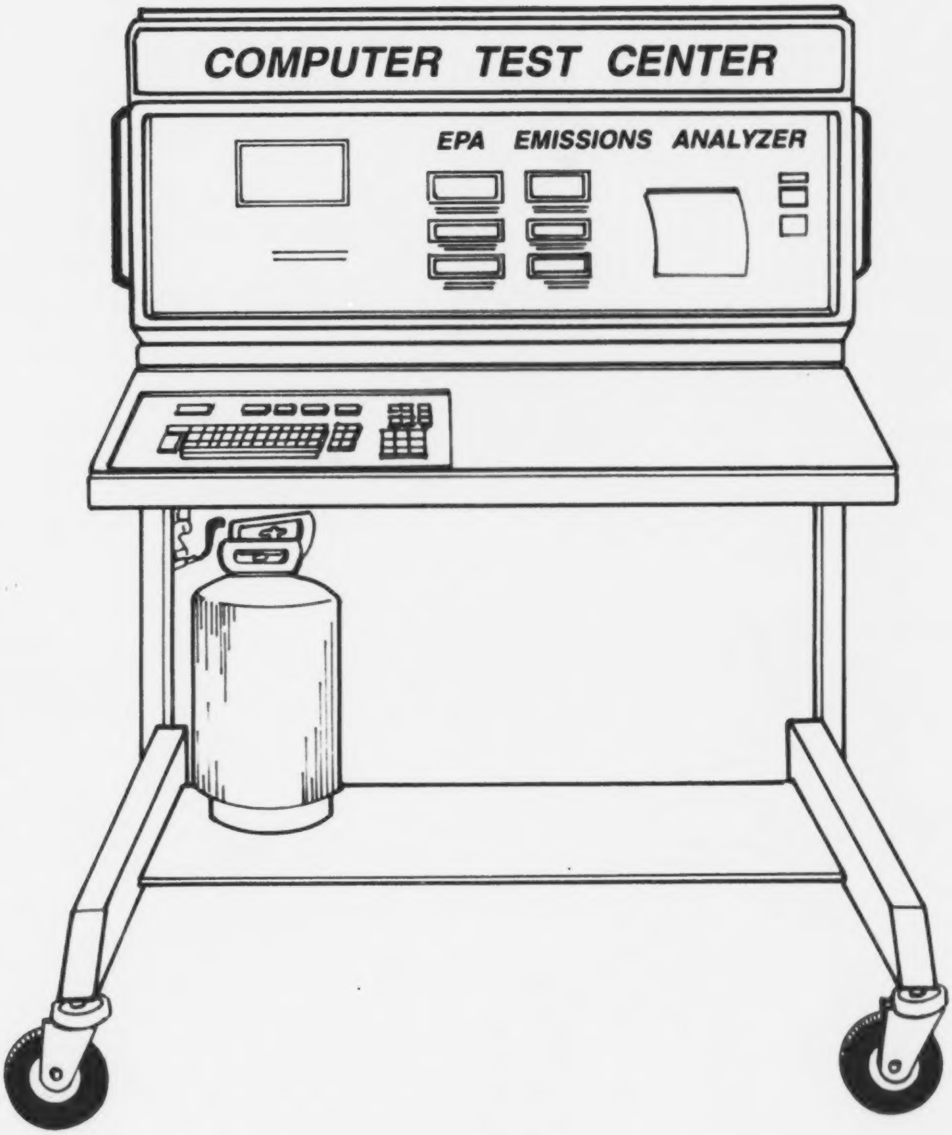
Exhaust Gas Analyzer


COMPUTER TEST CENTER
EPA EMISSIONS ANALYZER

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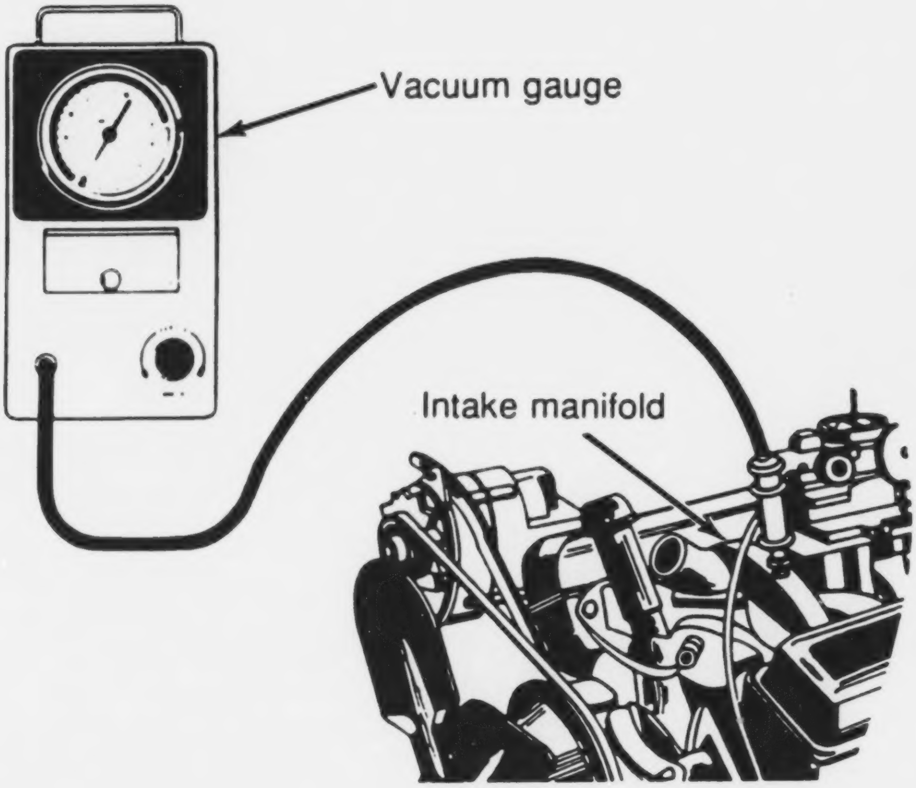
Vacuum Gauge


Vacuum gauge
Intake manifold

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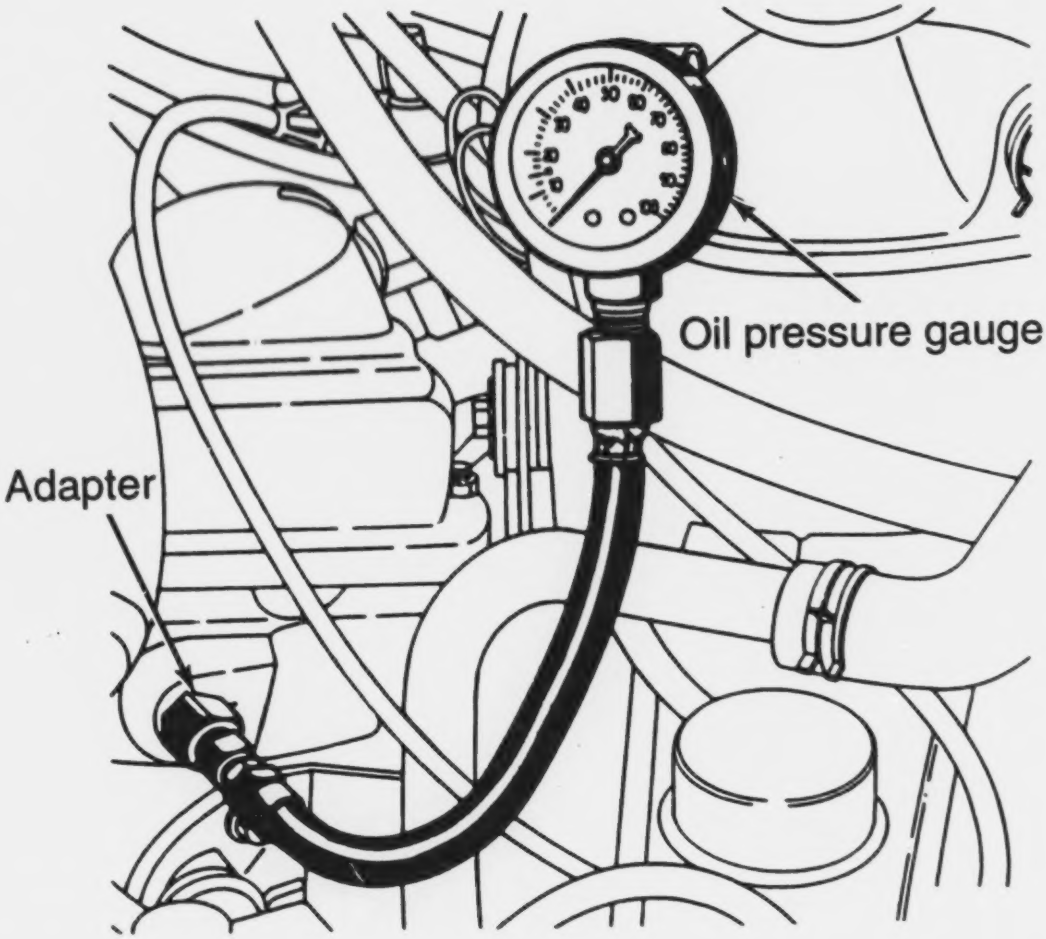
Pressure Gauge


Oil pressure gauge
Adapter

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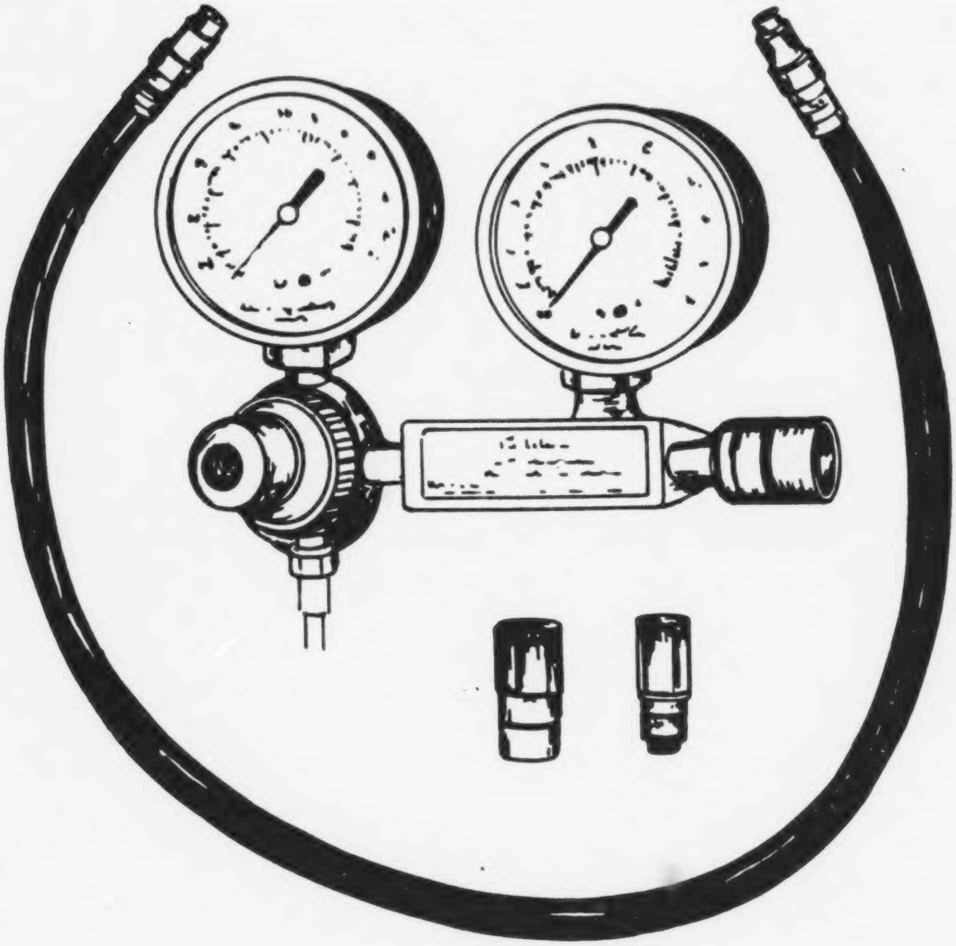
Cylinder Leakage Tester



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WRITTEN TEST

EVALUATING ENGINE CONDITION

5

Name ______________________ Date __________ Score ____

OBJECTIVE 1

List the major steps that should be included in an engine tune-up. Write the major steps in the blank lines provided below.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

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OBJECTIVE 2

Compare and contrast valve train timing and ignition timing. Place an X on the blank line under the valve train timing or ignition timing column if the statement applies to that type of timing.

	Valve Train Timing	Ignition Timing
1. Electronically controlled	________	________
2. Valve opens in relation to piston position	________	________
3. Mechanically controlled	________	________
4. Critical to effective emission control	________	________
5. Spark plugs fire in relation to the position of the engine pistons.	________	________
6. Faulty timing may cause the engine to run rough.	________	________

OBJECTIVE 3

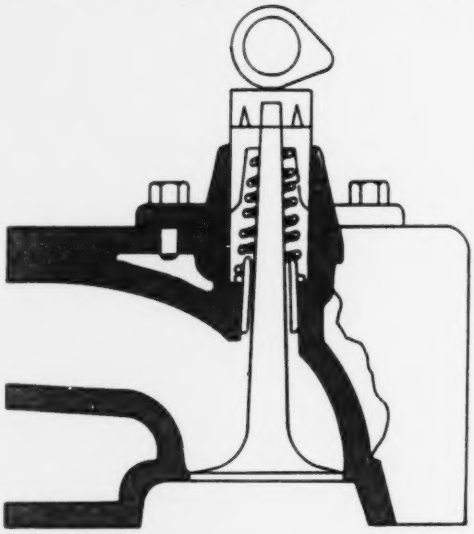
Give reasons why valve train timing is important to correct engine operation. Write the reasons on the blank lines below.

1. ____
2. ____
3. ____

May be photocopied for student use.

OBJECTIVE 4

Name types of valve trains shown in illustrations. Name the type of valve train in the blank space below each illustration.



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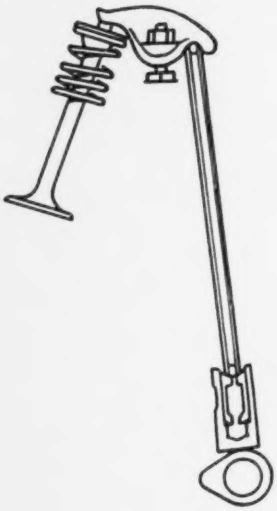
1. ______________________________



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2. ______________________________

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OBJECTIVE 5

Match the names of valve train parts to descriptions of their functions. Write the letter of the correct valve train part on the blank line in front of the description of its function.

A. camshaft
B. cylinder head
C. pushrod
D. rocker arm
E. valve
F. valve lifter
G. valve spring

____ 1. Operates the valve train

____ 2. Keeps the valve in the normally closed position

____ 3. Transfers motion from the cam to the pushrod

____ 4. Transfers motion between the valve lifter and the rocker arm

____ 5. Closes off the top of the cylinders and contains the valves and the parts through which the flow of the air-fuel mixture is regulated

____ 6. Transfers motion from the pushrod to the valve

____ 7. Controls the flow of the air-fuel mixture into and out of the engine cylinder

OBJECTIVE 6

List three ways the camshaft part of a valve train is driven. Write the three ways on the blank lines below.

1. ______________________________

2. ______________________________

3. ______________________________

OBJECTIVE 7

Evaluated on Job Sheet 1.

OBJECTIVE 8

Evaluated on Job Sheet 2.

OBJECTIVE 9

Evaluated on Job Sheet 3.

OBJECTIVE 10

Evaluated on Job Sheet 4.

May be photocopied for student use.

OBJECTIVE 11

Evaluated on Assignment Sheet 1.

OBJECTIVE 12

State reasons why a vehicle may require use of high octane fuel. Write the reasons on the lines below.

1. ______________________________

2. ______________________________

OBJECTIVE 13

List problems which may be created by using high octane fuel in a vehicle designed to use regular fuel. Write the problems on the lines below.

1. ______________________________

2. ______________________________

3. ______________________________

OBJECTIVE 14

List problems which may be created by using regular fuel in a vehicle designed to use high octane fuel. Write the problems on the lines below.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

May be photocopied for student use.

OBJECTIVE 15

List common engine performance problems. Write the problems on the lines below.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

OBJECTIVE 16

List common causes of engine mechanical problems. Write the causes on the lines below.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

OBJECTIVE 17

List common causes of engine lubrication problems. Write the causes on the lines below.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

OBJECTIVE 18

List common causes of engine overheating. Write the causes on the lines below.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

May be photocopied for student use.

OBJECTIVE 19

List engine parts that are most frequently affected by normal engine wear and tear. Write the parts on the lines below.

1. ________________________

2. ________________________

3. ________________________

OBJECTIVE 20

List the steps of engine inspection. Write the steps on the lines below.

1. ________________________

2. ________________________

3. ________________________

4. ________________________

5. ________________________

6. ________________________

OBJECTIVE 21

Evaluated on Job Sheet 5.

May be photocopied for student use.

OBJECTIVE 22

Match colors of exhaust to the condition or problem indicated by the color. Write the letter of the color next to the statement describing the condition or problem. Colors may be used more than once.

A. black
B. blue-gray
C. colorless
D. white

_____ 1. Excessive oil consumption

_____ 2. Incomplete burning of a normal air-fuel mixture

_____ 3. Normal

_____ 4. Water, coolant, or transmission fluid leakage into the cylinders

_____ 5. Too much fuel in the air-fuel mixture

OBJECTIVE 23

Describe an abnormal exhaust odor and the problem it indicates. Write your answers on the lines provided.

1. Abnormal exhaust odor: ____________________________

2. Problem indicated by this odor: ______________________

____

OBJECTIVE 24 **Evaluated on Assignment Sheet 2.**

OBJECTIVE 25 **Evaluated on Job Sheet 6.**

OBJECTIVE 26 **Evaluated on Assignment Sheet 3.**

OBJECTIVE 27 **Evaluated on Job Sheet 7.**

OBJECTIVE 28 **Evaluated on Job Sheet 8.**

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OBJECTIVE 29

Match the names of engine diagnostic tests to the engine conditions they evaluate. Write the letter of the correct engine diagnostic test in the blank beside the engine condition it evaluates.

A. cylinder compression test
B. cylinder leakage test
C. cylinder power balance test
D. oil pressure test
E. vacuum test

_____ 1. Measures the amount of pressure produced during the engine compression stroke

_____ 2. Measures lubrication system pressure in the engine

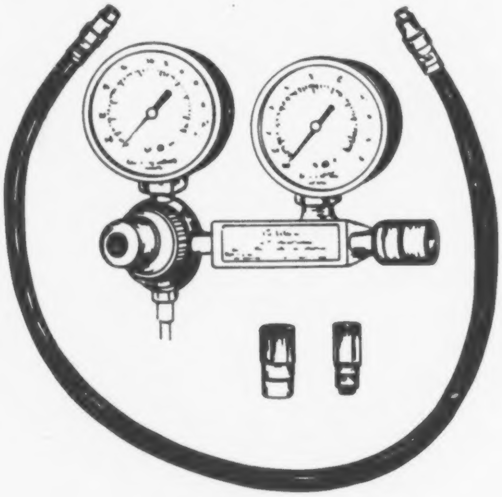
_____ 3. Measures the negative pressure (vacuum) produced by the engine

_____ 4. Measures the amount of air that leaks from each combustion chamber

_____ 5. Indicates which cylinders are not producing their share of power

OBJECTIVE 30

Name types of engine test equipment shown in illustrations. Write the correct name of engine test equipment on the line under each illustration.



1. ____

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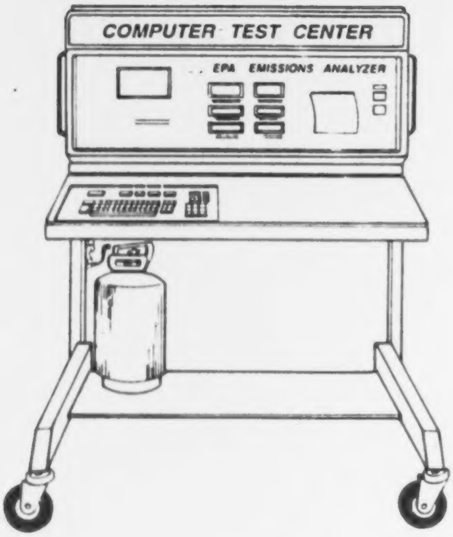
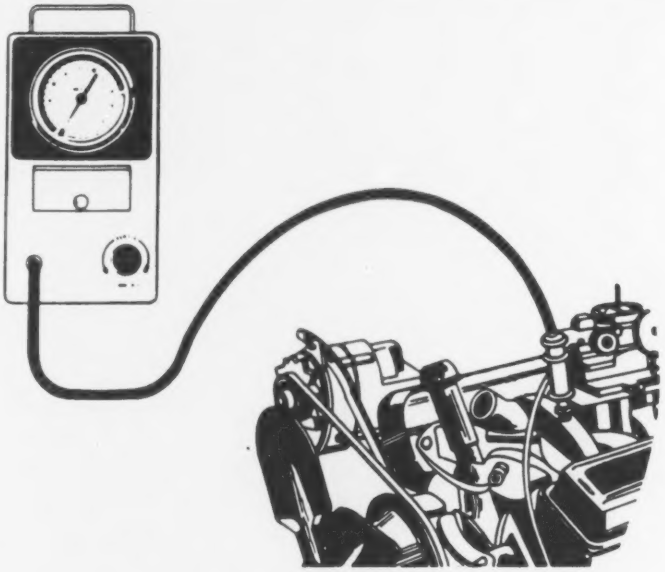

COMPUTER TEST CENTER
EPA EMISSIONS ANALYZER

2. ____



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3. ____

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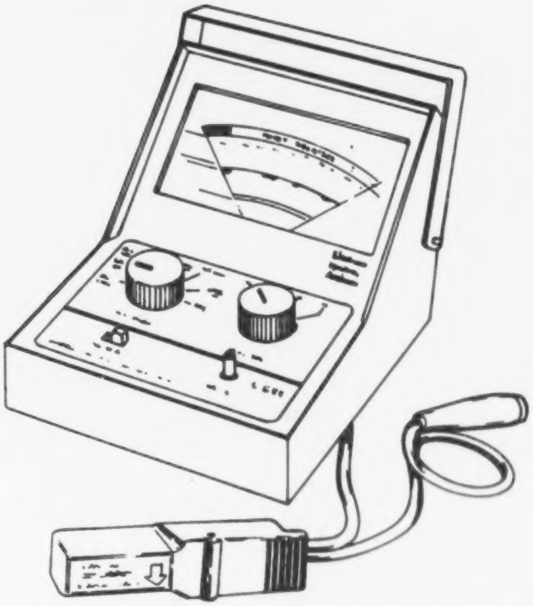
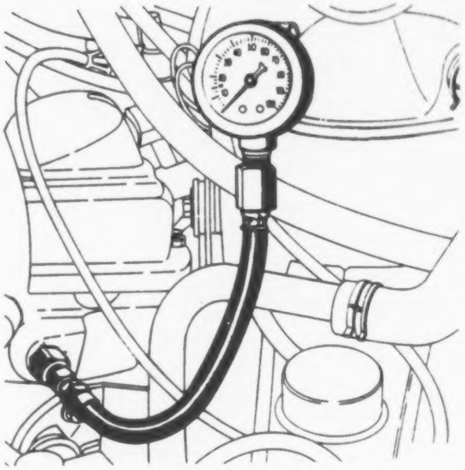


4. ______________________________



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5. ______________________________

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OBJECTIVE 31

Match the names of engine test equipment to the information which can be obtained with that equipment. Write the letter of the correct engine diagnostic test equipment in the blank beside the information which can be obtained with that equipment.

A. cylinder leakage tester
B. exhaust gas analyzer
C. pressure gauge
D. tach-dwell meter
E. vacuum gauge

Measures:

_____ 1. Pressure

_____ 2. Negative pressure

_____ 3. Chemical content of the engine's exhaust

_____ 4. Engine speed (rpm) and dwell angle

_____ 5. Amount of air leakage out of the engine combustion chambers

OBJECTIVE 32

List the steps in making a diagnostic road test. Write the steps on the lines below.

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____

OBJECTIVE 33

Evaluated on Assignment Sheet 4.

OBJECTIVE 34

Evaluated on Assignment Sheet 5.

May be photocopied for student use.

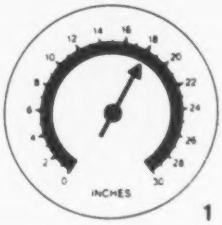
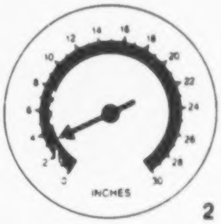
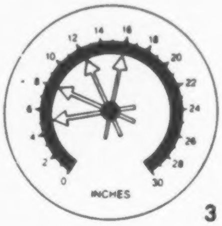
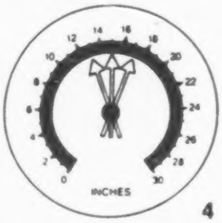
Compression Diagnosis Chart

The most probable causes are listed first.

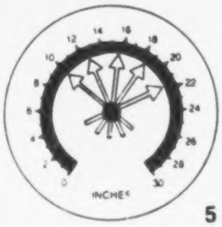
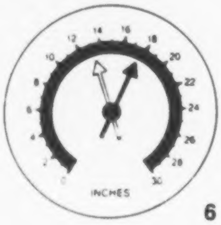
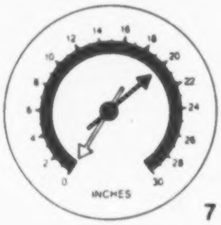
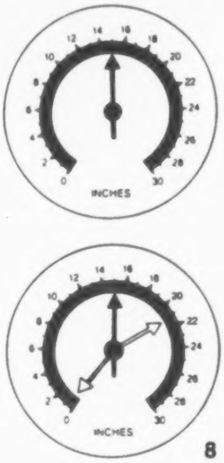
CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Too High	Slack timing chain/belt	Replace parts as needed.
	Exhaust restriction	Replace parts as needed.
	Carbon deposits on top of the piston	Decarbonize the engine.
Too low	Slack timing chain/belt	Replace parts as needed.
	Damaged Valves	Replace valves.
	Burned valve	Replace valve.
	Defective head gasket	Replace head gasket; surface head.
	Burned piston	Replace piston.
	Misadjusted valve	Adjust valve.
	Worn or broken piston rings	Replace piston rings.
	Cracked cylinder head	Repair or replace cylinder head.

May be photocopied for student use.

Interpreting Engine Vacuum Readings

	READING	DIAGNOSIS
 1	Average and steady at 17-21	Everything is normal.
 2	Extremely low reading — needle holds steady.	Air leak at the intake manifold or throttle body; incorrect timing
 3	Needle fluctuates between high and low reading.	Defective valve train component or blown head gasket between two side-by-side cylinders (Check with cylinder leakage test.)
 4	Needle fluctuates very slowly, ranging 4 or 5 inches.	Spark plug gap too narrow, sticking valves

Interpreting Engine Vacuum Readings (continued)

	READING	DIAGNOSIS
 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 INCHES 5	Needle fluctuates rapidly at idle—steadies as rpm is increased.	Worn valve guides
 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 INCHES 6	Needle drops to low reading, returns to normal, drops back, etc., at a regular interval.	Burned or leaking valve
 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 INCHES 7	Needle drops to zero as engine rpm is increased.	Restricted exhaust system
 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 INCHES 8	Needle holds steady at 12 to 16—drops to 0 and back to about 21 as you open and release the throttle.	Leaking piston rings (Check with compression test.)

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Engine Noise Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Heavy metallic knock	Worn crankshaft bearings	Replace bearings; check crankshaft and service as necessary.
	Damaged thrust bearings	Replace thrust bearings.
	Out-of-round crankshaft journal	Service or replace crankshaft.
	Dry crankshaft	Check lubrication system; repair as necessary.
Clattering/knocking sound or light raps, changes with engine speed	Worn connecting rod bearings	Replace connecting rod bearings; check connecting rod.
	Out-of-round crankshaft journal	Service or replace crankshaft.
	Misaligned connecting rod	Service or replace connecting rod.
Hollow, bell-like knock, loudest when engine is cold, sometimes disappears when engine is warm	Broken or collapsed piston skirt	Replace piston.
Metallic, double-knock sound, most noticeable when engine is idling	Loose piston pin or bushing	Replace piston pin or bushing.

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Engine Noise Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Clicking sound, with clicks heard at a frequency of one-half crankshaft speed	Worn or damaged lifter	Replace lifter.
	Improper valve adjustment	Adjust valves.
	Bent pushrod	Replace pushrod.
	Worn rocker arms	Replace rocker arms.
	Worn valve guides	Replace valve guides.
	Worn valve spring	Replace valve spring.
	Loose valve seat	Replace valve seat.
	Worn cam lobes	Replace cam lobes.
Squeal	Worn or loose belts	Inspect belts; replace or tighten.
Rattle under acceleration	Loose or broken manifold heat control valve	Tighten or replace manifold heat control valve.
Popping noise from top of carburetor	Slack timing chain/belt	Replace timing chain/belt and parts.
	Burnt valves	Replace valves.
	Flat exhaust lobe on camshaft	Replace camshaft.
Loud internal engine noises	Bent or broken rod	Replace rod.
	Coolant in cylinder	Check for coolant leak; repair if found.

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LAP SHEET

UNDERSTANDING ENGINE COMPUTER CONTROLS

6

Name ____

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

2. **Read** ____ the introduction, unit objective, and specific objectives.

3. **Do** ____ the focus assignments.

4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.

5. **Study** ____ the Information Sheet, objective 1.

6. **Examine** ____ an example of a sensor, an engine computer, and a control device and ask your instructor to explain how these components work together.

7. **Examine** ____ engine computer control devices on an actual vehicle.

8. **Read** ____ the Handout.

Optional: Examine ____ examples of automotive computers other than the engine computer.

9. **Study** ____ the Information Sheet, objective 2.

10. **Examine** ____ examples of sensors on display in your classroom.

Optional: Write ____ the names of common sensors on one set of cards and their descriptions on another set of cards. Practice matching the names of the sensors to their correct descriptions.

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11. **Study** ____ the Information Sheet, objectives 3 and 4.

12. **Examine** ____ examples of control devices on display in your classroom.

Optional: Write ____ the names of common control devices on one set of cards and their descriptions on another set of cards. Practice Matching the names of the control devices to their correct descriptions.

13. **Study** ____ the Information Sheet, objectives 5, 6 and 7.

14. **Examine** ____ examples of an engine computer analyzer and a scan tool.

15. **Study** ____ the Information Sheet, objective 8.

16. **Ask** ____ your instructor to compare the types of engine computer analyzers.

17. **Study** ____ the introduction to the Job Sheet.

18. **Ask** ____ your instructor to explain what types of engine problems can be diagnosed with a scan tool and an engine computer analyzer.

19. **Ask** ____ your instructor to demonstrate how improper hook-up of engine computer analyzers can lead to inaccurate or no results on tests that are performed.

20. **Ask** ____ your instructor to demonstrate the guidelines and procedures in the Job Sheet. Use the appropriate equipment and service manuals to follow along. Pay careful attention to any guidelines, cautions, and warnings.

21. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate equipment and service manuals as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

22. **Stop** ____ and have your instructor evaluate your work. After your work has been evaluated, follow your instructor's recommendations.

23. **Take** ____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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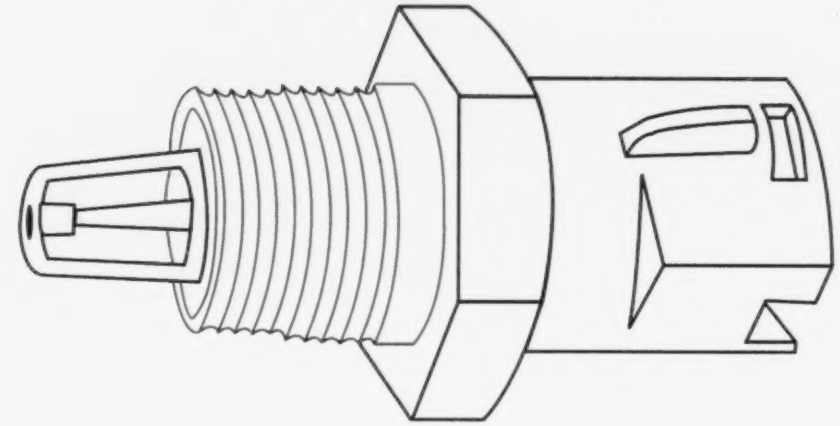
Air Charge Sensor (ACS)



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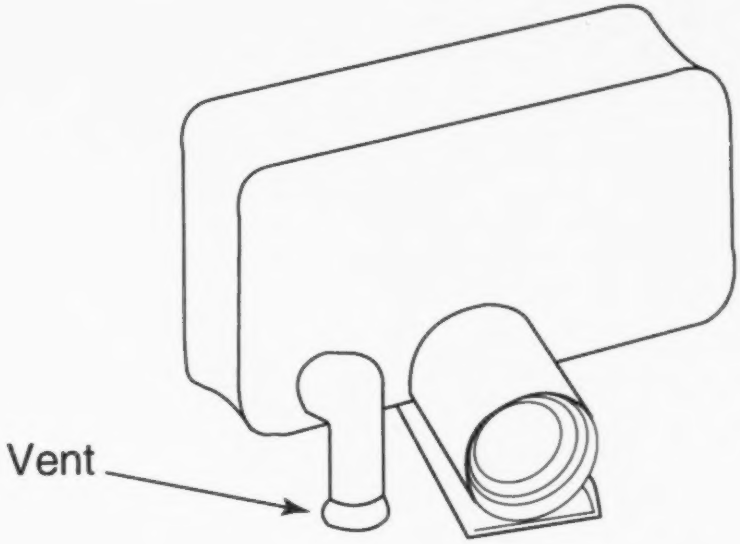
Barometric Pressure Sensor (BAP)



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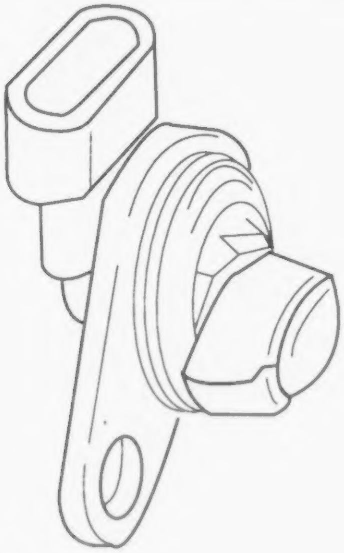
Camshaft Position Sensor



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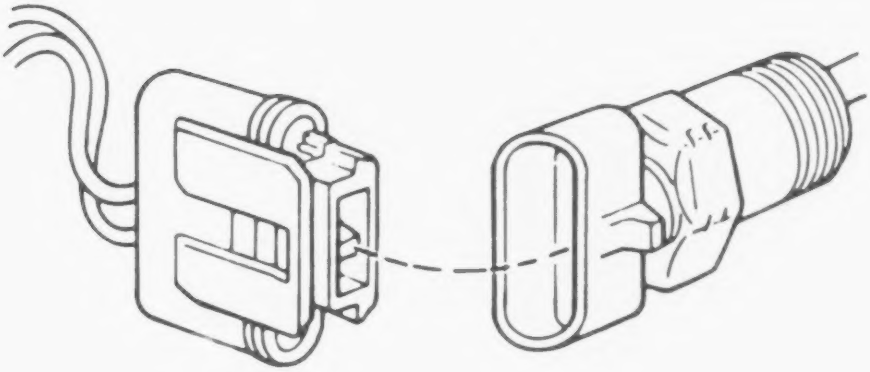
Coolant Temperature Sensor (CTS)



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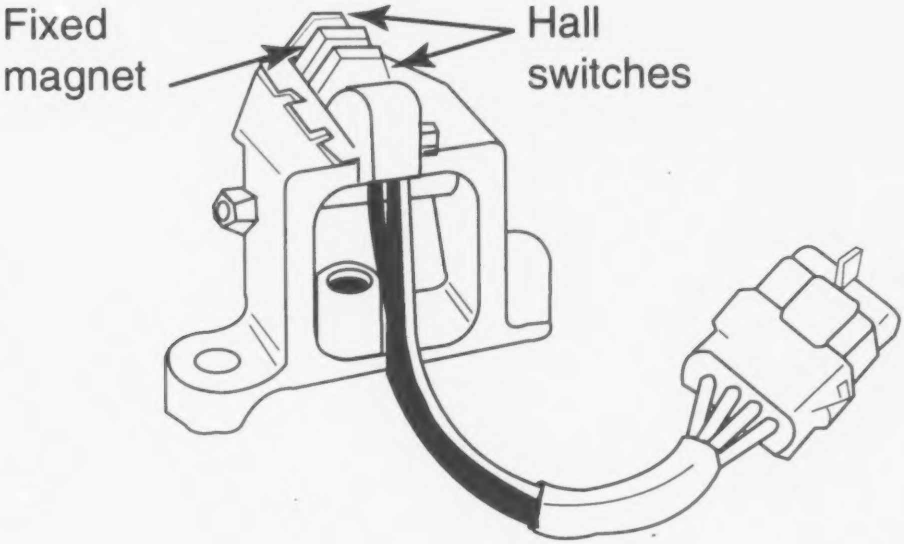
Crankshaft Position Sensor


Fixed magnet
Hall switches

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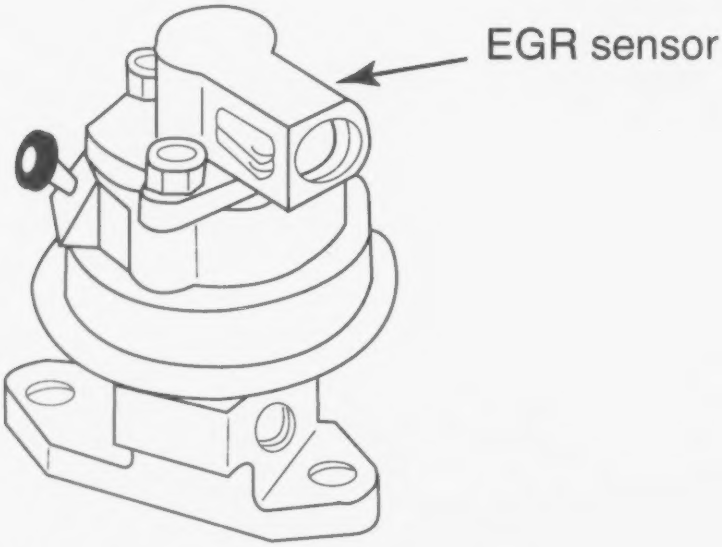
Exhaust Gas Recirculation (EGR) Sensor (EVP)



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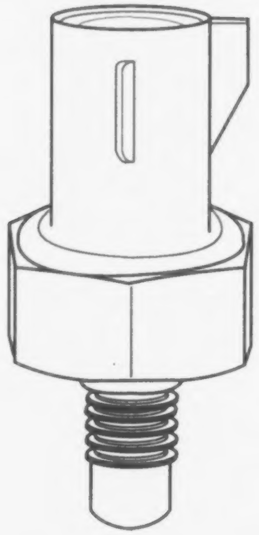
Knock Sensor



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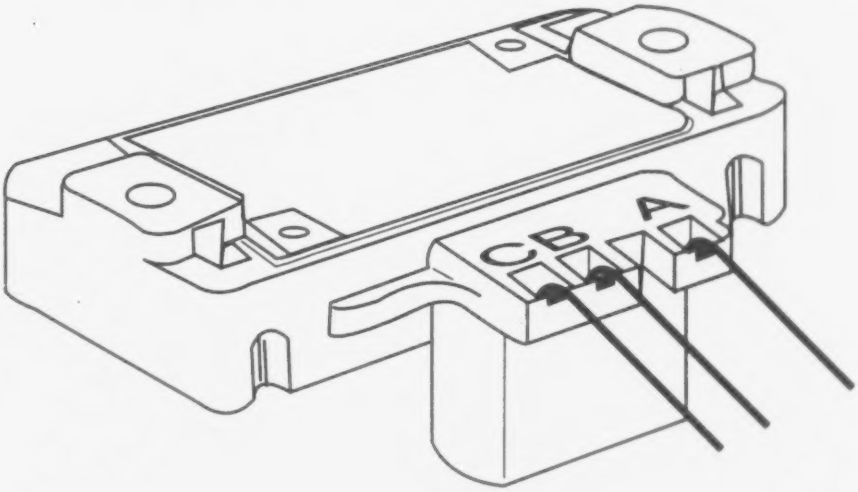
Manifold Absolute Pressure (MAP) Sensor



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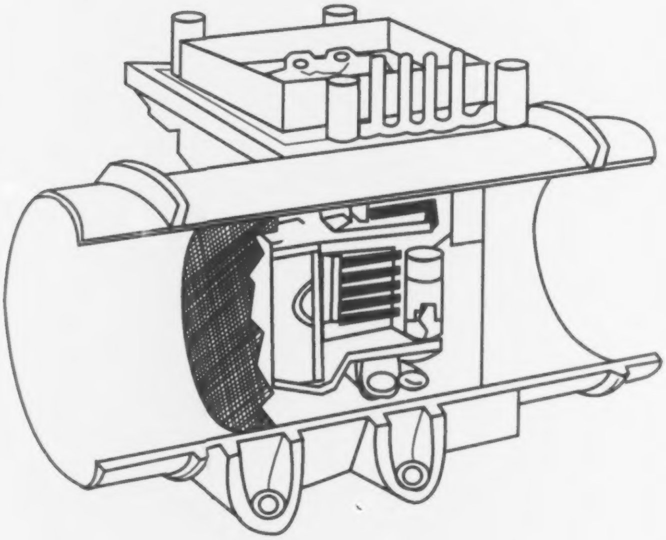
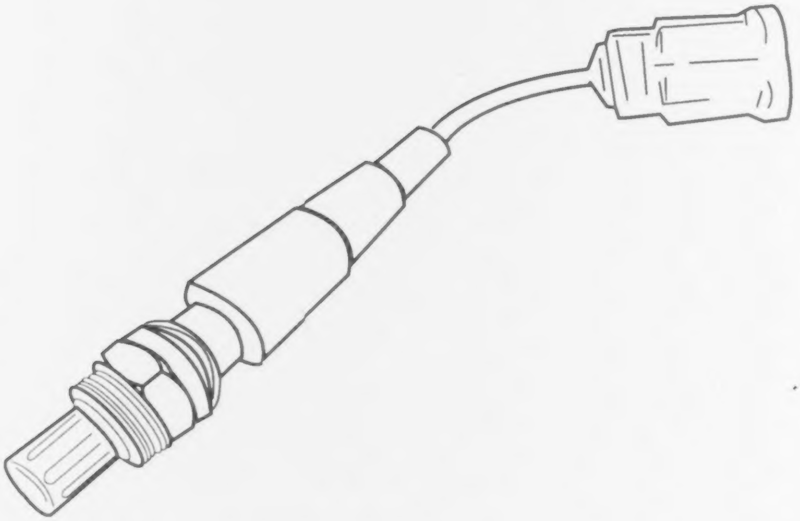
Mass Air Flow (MAF) Sensor



Oxygen (O_2) Sensor



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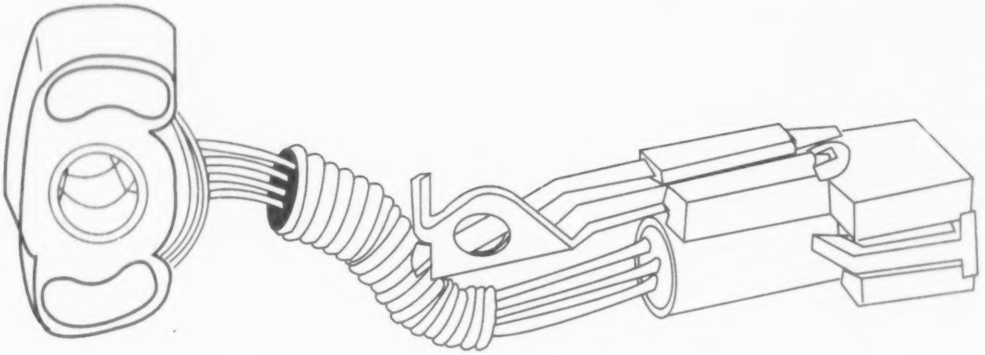
Throttle Position Sensor (TPS)



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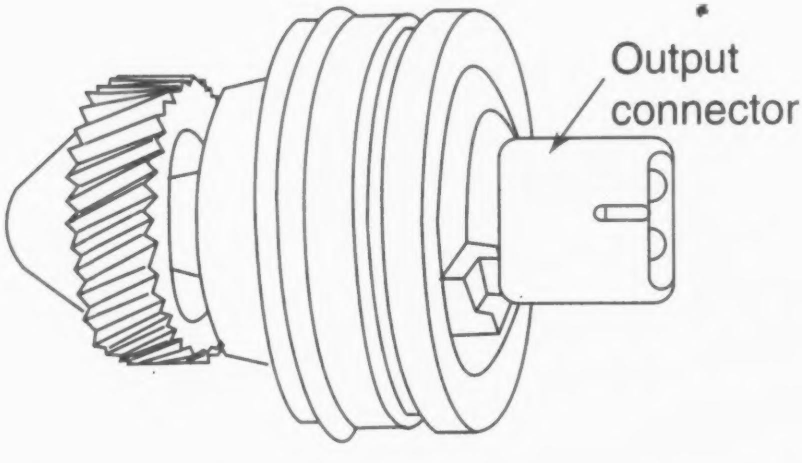
Vehicle Speed Sensor (VSS)



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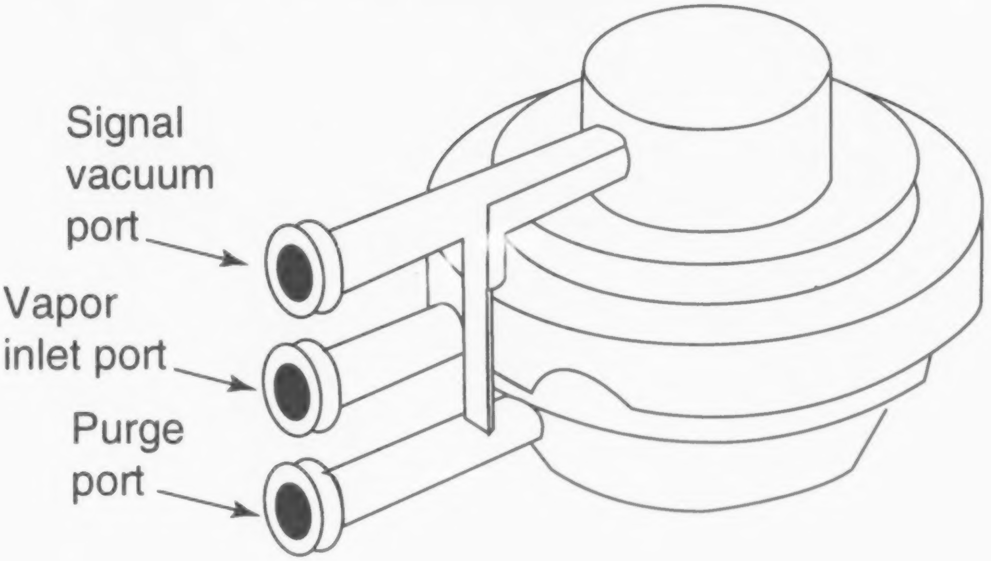
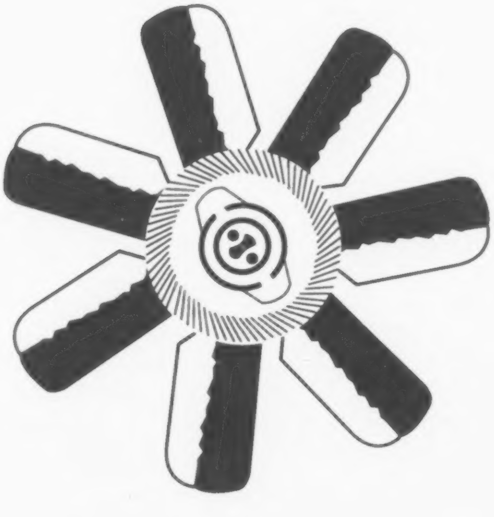
Carbon Canister Purge Valve

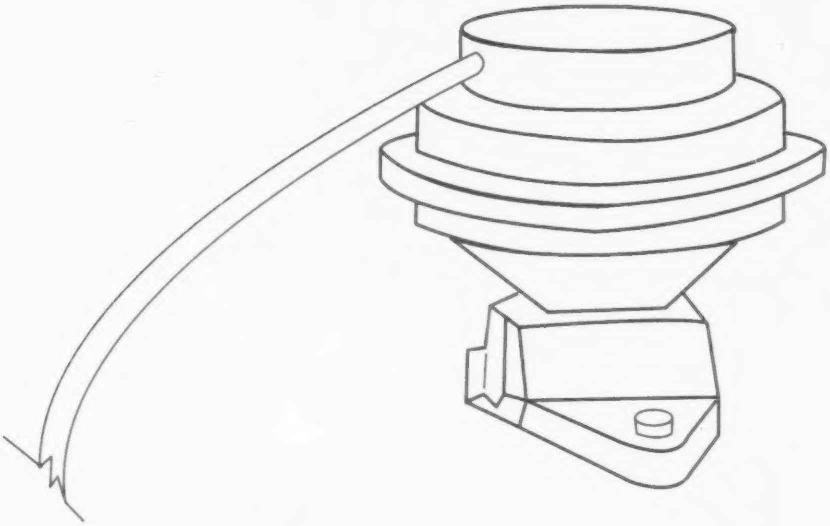

Signal vacuum port
Vapor inlet port
Purge port

Engine Cooling Fan

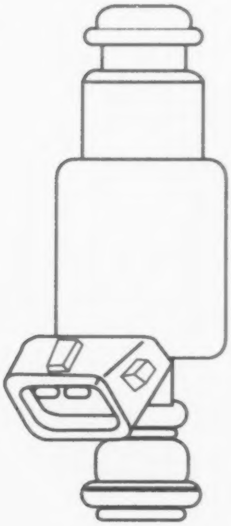


May be photocopied for student use.

Exhaust Gas Recirculation Valve



Fuel Injector



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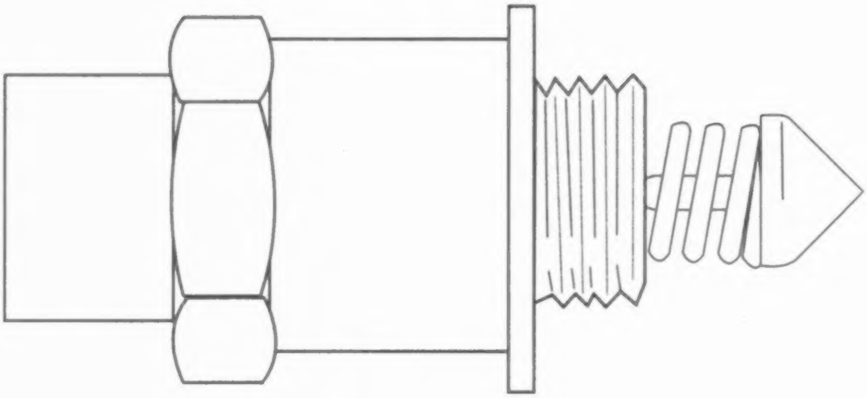
Idle Air Control Valve



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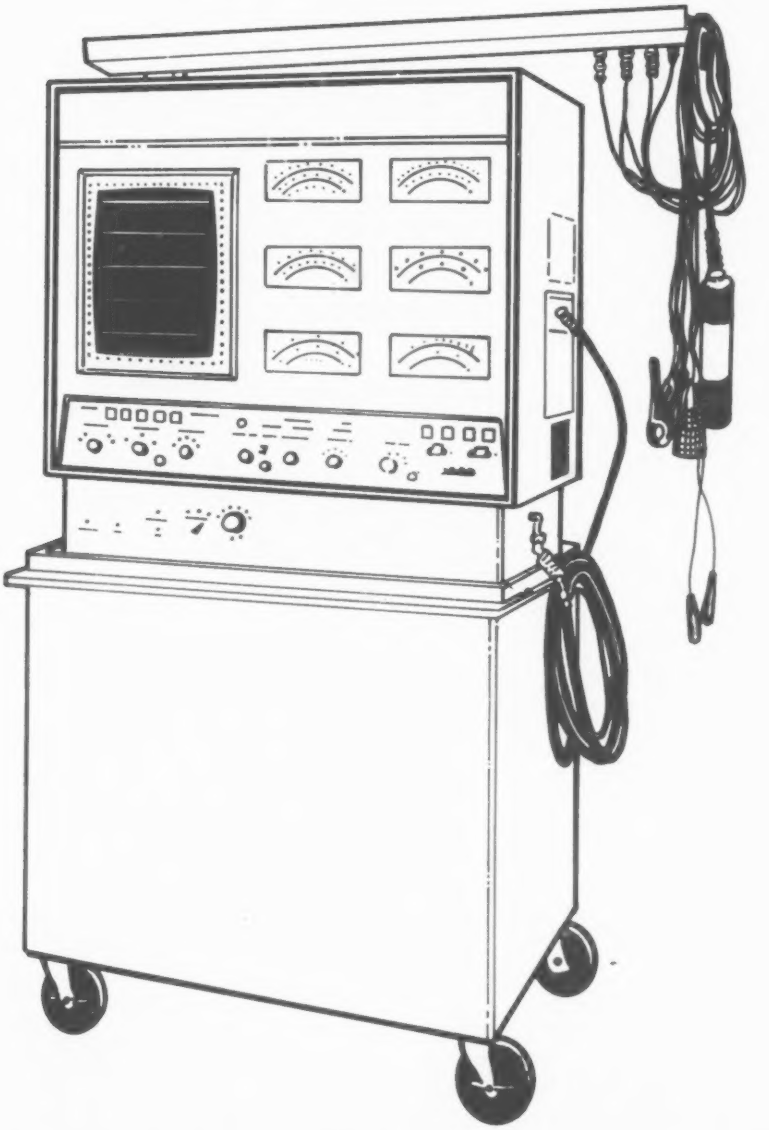
Engine Computer Analyzer



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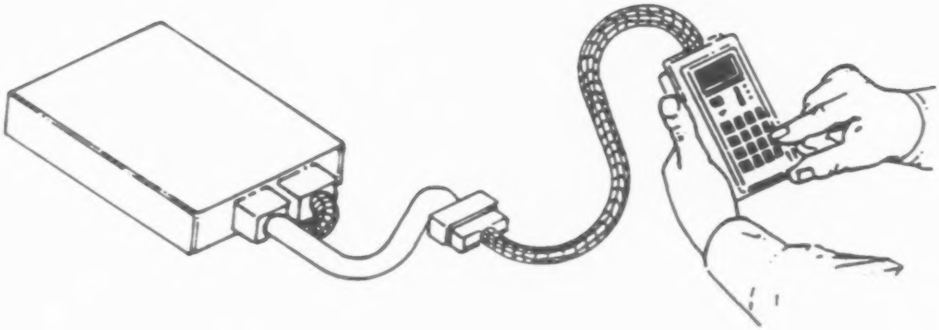
Scan Tool



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WRITTEN TEST

UNDERSTANDING ENGINE COMPUTER CONTROLS

6

Name ______________________ Date __________ Score ____

OBJECTIVE 1

Describe the functions of the three main components of the engine computer control system. Write a description of the function beside the names of the components.

1. sensors: ______________________________

____

____

2. engine computer: ______________________________

____

____

3. control devices: ______________________________

____

____

OBJECTIVE 2

Match the names of common sensors to the function monitored by the sensor. Write the letter of the correct answer in the blank to the left of the function.

A. air charge sensor (ACS)
B. barometric pressure sensor (BAP)
C. camshaft position sensor
D. coolant temperature sensor (CTS)
E. crankshaft position sensor
F. distributor reference sensor
G. exhaust gas recirculation (EGR) sensor (EVP)
H. knock sensor
I. manifold absolute pressure (MAP) sensor
J. mass air flow (MAF) sensor
K. oxygen (O_2) sensor
L. throttle position sensor (TPS)
M. vehicle speed sensor (VSS)

____ 1. Measures the amount of outside air flowing into the intake manifold

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____ 2. **Measures the temperature of the air entering the engine for combustion**

____ 3. Reports engine speed and the position of the #1 piston

____ 4. Monitors the position of the EGR valve

____ 5. Monitors the oxygen content of exhaust gases

____ 6. Reports how fast the vehicle is moving

____ 7. Measures barometric pressure

____ 8. Measures the pressure inside the intake manifold

____ 9. Reports camshaft and valve position of the #1 piston

____ 10. Measures the temperature of the coolant

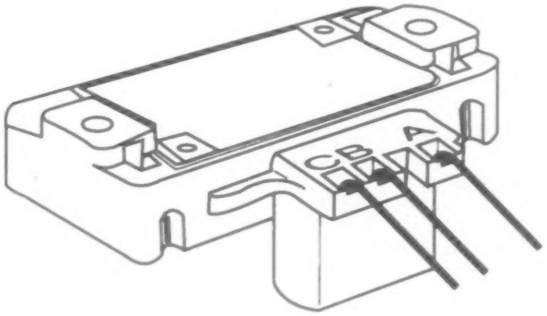
____ 11. Reports vibrations in the engine

____ 12. Reports engine speed (rpm)

____ 13. Monitors the position of the gas pedal

OBJECTIVE 3

Match the names of common sensors to illustrations of the sensors. Using the list in objective 2, write the name of the sensor pictured under the illustration.



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1. Sensor: ______________________________

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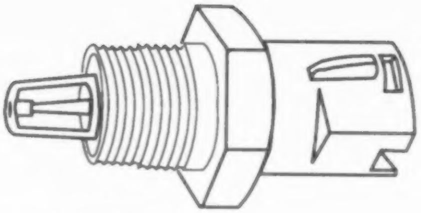

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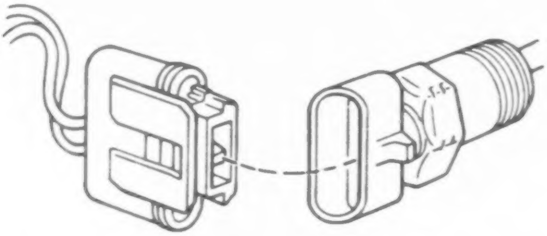
2. Sensor: ____



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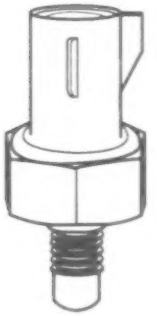
3. Sensor: ____



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4. Sensor: ____

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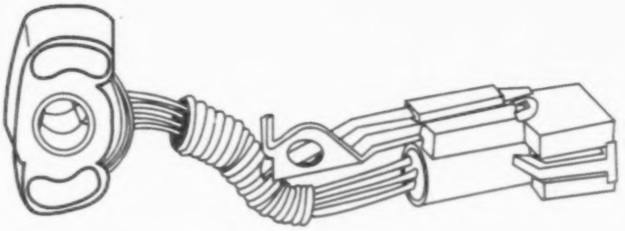

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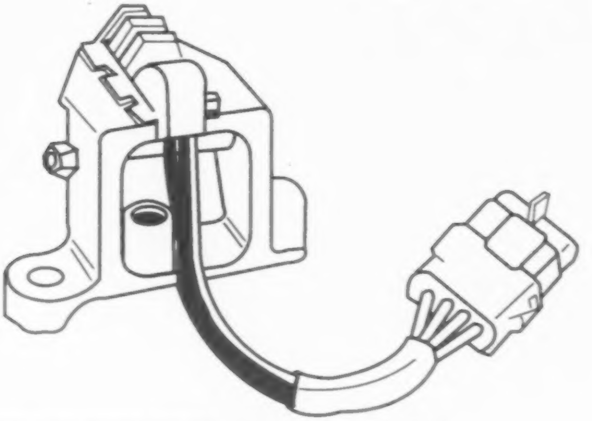
5. Sensor: ______________________________



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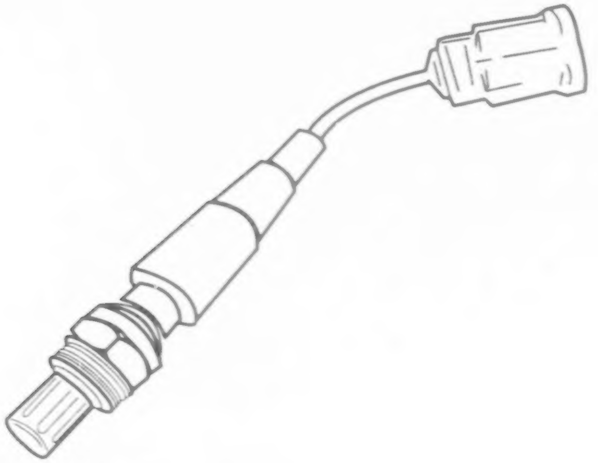
6. Sensor: ______________________________



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7. Sensor: ______________________________

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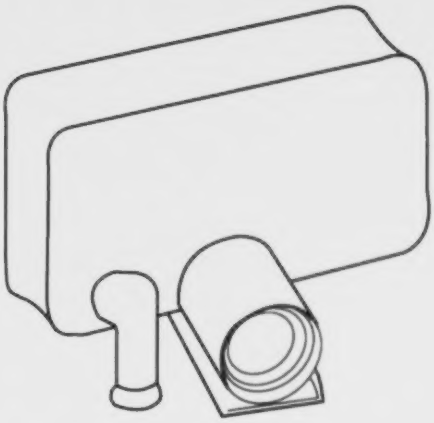
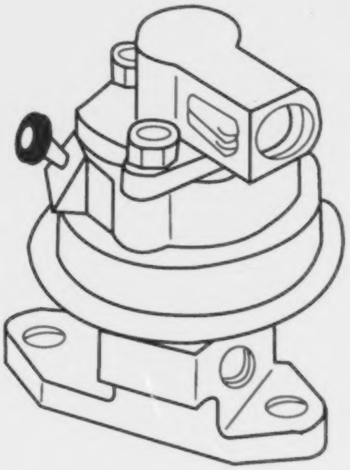


8. Sensor: ______________________________



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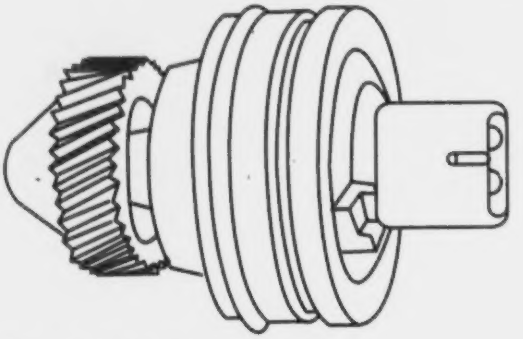
9. Sensor: ______________________________



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10. Sensor: ______________________________

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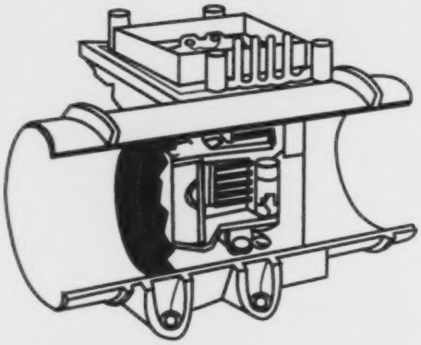
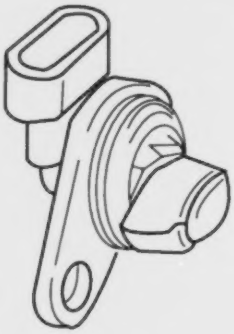


11. Sensor: ____



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12. Sensor: ____

OBJECTIVE 4

Match the names of common control devices to the functions they control. Write the letter of the correct answer in the blank to the left of the function.

A. carbon canister purge valve
B. electronic spark timing device
C. engine cooling fan
D. exhaust gas recirculation valve
E. fuel injector
F. idle air control valve

____ 1. Allows a controlled amount of exhaust gas to return to the intake manifold, thereby reducing combustion temperature and therefore emissions

____ 2. Adjusts ignition timing

____ 3. Releases fuel vapors to the intake manifold when a richer air-fuel mixture is required

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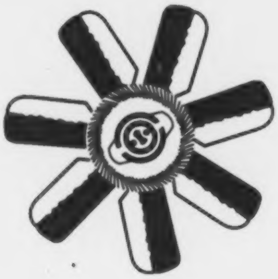
____ 4. Adjusts air flow to increase engine idle speed

____ 5. Cools the radiator when the coolant is too hot

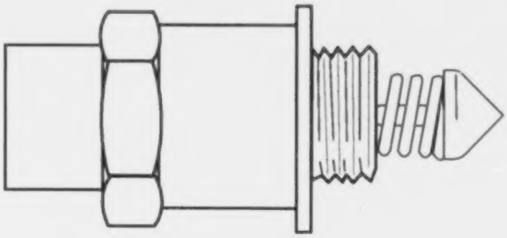
____ 6. Controls the amount of fuel entering the engine

OBJECTIVE 5

Match the names of common control devices to illustrations of the devices. Using the list in objective 4, write the name of the control device pictured under the illustration.



1. Control device: ______________________________



2. Control device: ______________________________

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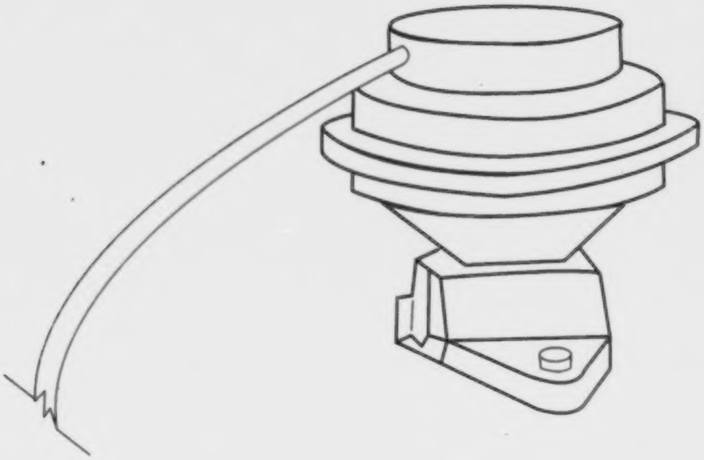
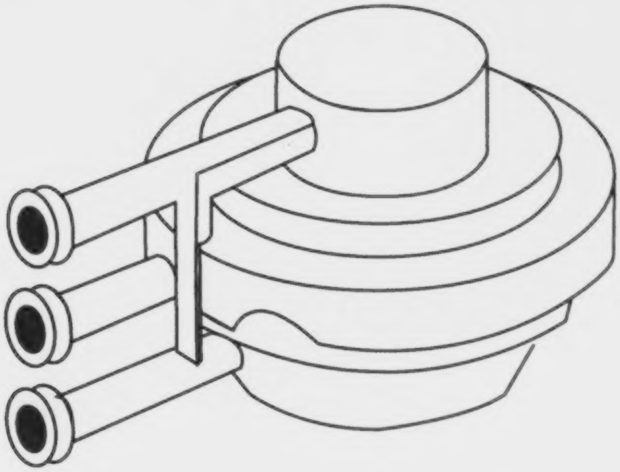


3. Control device: ______________________________



4. Control device: ______________________________

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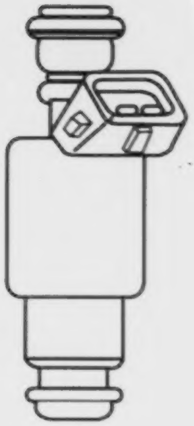

5. Control device: ____________________

OBJECTIVE 6

List information that can be monitored by an engine computer analyzer. Write the information in the blanks below.

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________

8. ____________________

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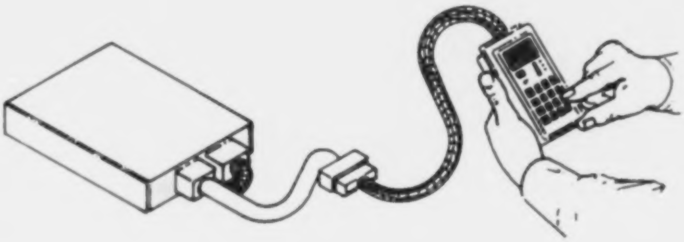
OBJECTIVE 7

Name types of engine computer analyzers shown in illustrations. Write the name of the type of engine computer analyzer in the blank below the illustration.



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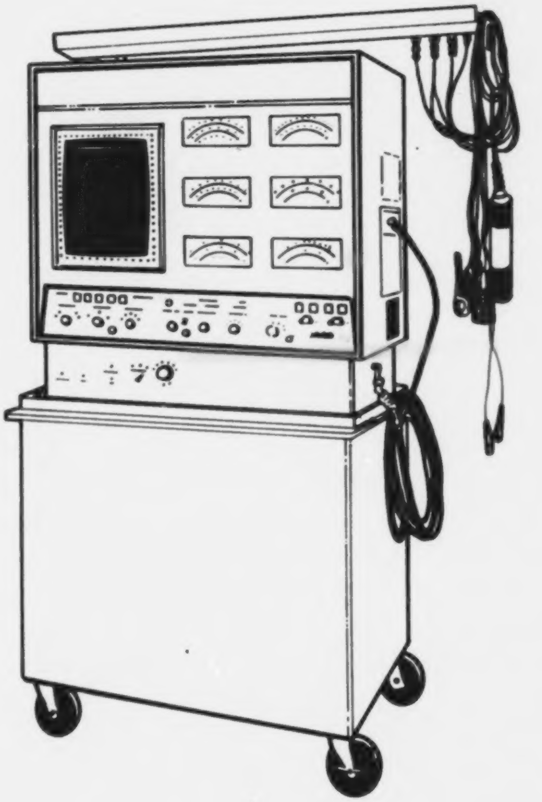
1. ____________________



2. ____________________

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OBJECTIVE 8

Compare and contrast engine computer analyzers and scan tools. Write how engine computer analyzers compare with scan tools on the lines below each feature.

1. What type of power is required to operate this engine analyzer?

   A. Scan tools ______________________

   ____

   B. Engine computer analyzers ______________________

   ____

2. How much information can be displayed in the window of this analyzer?

   A. Scan tools ______________________

   ____

   B. Engine computer analyzers ______________________

   ____

3. Can data from systems other than the engine computer system be monitored?

   A. Scan tools ______________________

   ____

   B. Engine computer analyzers ______________________

   ____

4. How can the data in the memory be updated?

   A. Scan tools ______________________

   ____

   B. Engine computer analyzers ______________________

   ____

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5. Can a paper printout be produced by this analyzer?

A. Scan tools ______________________________

____

B. Engine computer analyzers ______________________________

____

6. What is the approximate cost of this type analyzer?

A. Scan tools ______________________________

____

B. Engine computer analyzers ______________________________

____

7. Can this analyzer be used during test drives?

A. Scan tools ______________________________

____

B. Engine computer analyzers ______________________________

____

8. What size is this type of engine analyzer?

A. Scan tools ______________________________

____

B. Engine computer analyzers ______________________________

____

9. Is this analyzer available with an exhaust gas analyzer?

A. Scan tools ______________________________

____

B. Engine computer analyzers ______________________________

____

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10. How many engine hook-ups can be used with this analyzer?

A. Scan tools ____

____

B. Engine computer analyzers ____

____

11. What decision-making ability does this analyzer have?

A. Scan tools ____

____

B. Engine computer analyzers ____

____

OBJECTIVE 9 **Evaluated on the Job Sheet.**

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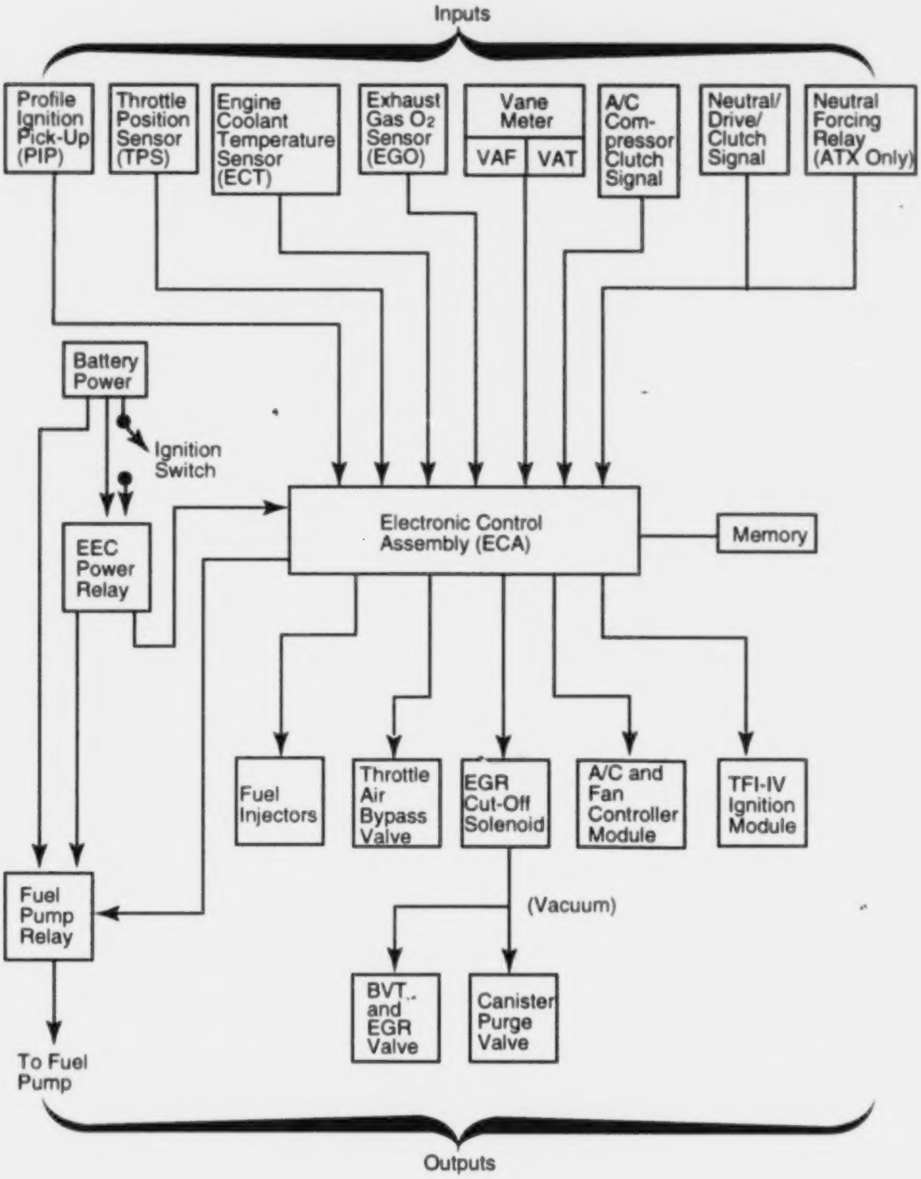
HANDOUT

UNDERSTANDING ENGINE COMPUTER CONTROLS

6

Automotive Computer Functions


Inputs
Profile Ignition Pick-Up (PIP)
Throttle Position Sensor (TPS)
Engine Coolant Temperature Sensor (ECT)
Exhaust Gas O2 Sensor (EGO)
Vane Meter
VAF
VAT
A/C Compressor Clutch Signal
Neutral/ Drive/ Clutch Signal
Neutral Forcing Relay (ATX Only)
Battery Power
Ignition Switch
EEC Power Relay
Electronic Control Assembly (ECA)
Memory
Fuel Injectors
Throttle Air Bypass Valve
EGR Cut-Off Solenoid
A/C and Fan Controller Module
TFI-IV Ignition Module
(Vacuum)
Fuel Pump Relay
BVT and EGR Valve
Canister Purge Valve
To Fuel Pump
Outputs

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LAP SHEET

SERVICING IGNITION SYSTEMS

7

Name ________________________________

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read** ____ the introduction, unit objective, and specific objectives.
3. **Do** ____ the focus assignments.
4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study** ____ the Information Sheet, objectives 1, 2, and 3.
6. **Ask** ____ your instructor to explain how the components of each type of ignition system shown in Figures 1, 2, and 3 operate together.
7. **Study** ____ the Information Sheet, objective 4.
8. **Ask** ____ your instructor to describe the function of each ignition system part as you examine the parts.
9. **Study** ____ the Information Sheet, objectives 5, 6, and 7.
10. **Ask** ____ your instructor to explain the similarities and differences between the types of ignition systems.
11. **Study** ____ the Information Sheet, objectives 8 and 9.
12. **Ask** ____ your instructor to show you types of triggering systems and explain their operation.
13. **Study** ____ the Information Sheet, objectives 10 through 13.

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14. **Ask** ____ your instructor to explain the operation of the ignition coil shown in Figure 5.

15. **Examine** ____ the parts of an actual ignition coil.

16. **Study** ____ the Information Sheet, objective 14.

17. **Ask** ____ your instructor to explain the operation of the distributors shown in Figures 6 and 7.

18. **Study** ____ the Information Sheet, objective 15.

19. **Ask** ____ your instructor to explain the operation of a spark plug shown in Figure 8.

20. **Study** ____ the Information Sheet, objective 16.

21. **Examine** ____ examples of different types of spark plugs.

22. **Study** ____ the Information Sheet, objective 17.

23. **Ask** ____ your instructor to explain the importance of each test.

24. **Study** ____ the Information Sheet, objectives 18 and 19.

25. **Draw** ____ a typical primary ignition oscilloscope pattern for an electronic distributor ignition using transparency 12 or Handout 1.

26. **Ask** ____ your instructor to check your drawing.

27. **Study** ____ the Information Sheet, objective 20.

28. **Draw** ____ a typical primary ignition oscilloscope pattern for a contact point ignition using transparency 13 or Handout 1.

29. **Ask** ____ your instructor to check your drawing.

30. **Study** ____ the Information Sheet, objective 21.

31. **Ask** ____ your instructor to show you transparency 14 and circle the area of an oscilloscope pattern which corresponds to oscilloscope ignition coil ON.

32. **Ask** ____ your instructor to check your drawing.

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33. Study ____ the Information Sheet, objective 22.

34. Ask ____ your instructor to show you transparency 14 and circle the area of an oscilloscope pattern which corresponds to oscilloscope ignition coil OFF.

35. Ask ____ your instructor to check your drawing.

36. Ask ____ your instructor to explain the term *dwell* and its use in ignition diagnosis.

37. Study ____ the introduction to Job Sheet 1.

38. Ask ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

39. Practice ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

40. Stop ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

41. Study ____ the introduction to Job Sheet 2.

42. Ask ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

43. Practice ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

44. Stop ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

45. Use ____ Handout 2 and examples of defective spark plugs to help you learn to diagnose spark plug conditions and their causes.

46. **Study** ____ the introduction to Job Sheet 3.

47. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

48. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

49. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

50. **Study** ____ the introduction to Job Sheet 4.

51. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

52. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

53. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

54. **Study** ____ the introduction to Job Sheet 5.

55. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 5. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

56. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

57. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

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58. **Study** _____ the introduction to Job Sheet 6.

59. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 6. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

60. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

61. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

62. **Study** _____ the Information Sheet, objectives 29 through 31.

63. **Study** _____ the introduction to Job Sheet 7.

64. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 7. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

65. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

66. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

67. **Study** _____ the introduction to Job Sheet 8.

68. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 8. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

69. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

70. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

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71. **Study** ____ the introduction to Job Sheet 9.

72. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 9. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

73. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

74. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

75. **Study** ____ the introduction to Job Sheet 10.

76. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 10. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

77. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

78. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

79. **Study** ____ the introduction to Job Sheet 11.

80. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 11. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

81. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

82. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

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83. **Study** _____ the Assignment Sheet.

84. **Complete** _____ the Assignment Sheet.

85. **Stop** _____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

86. **Take** _____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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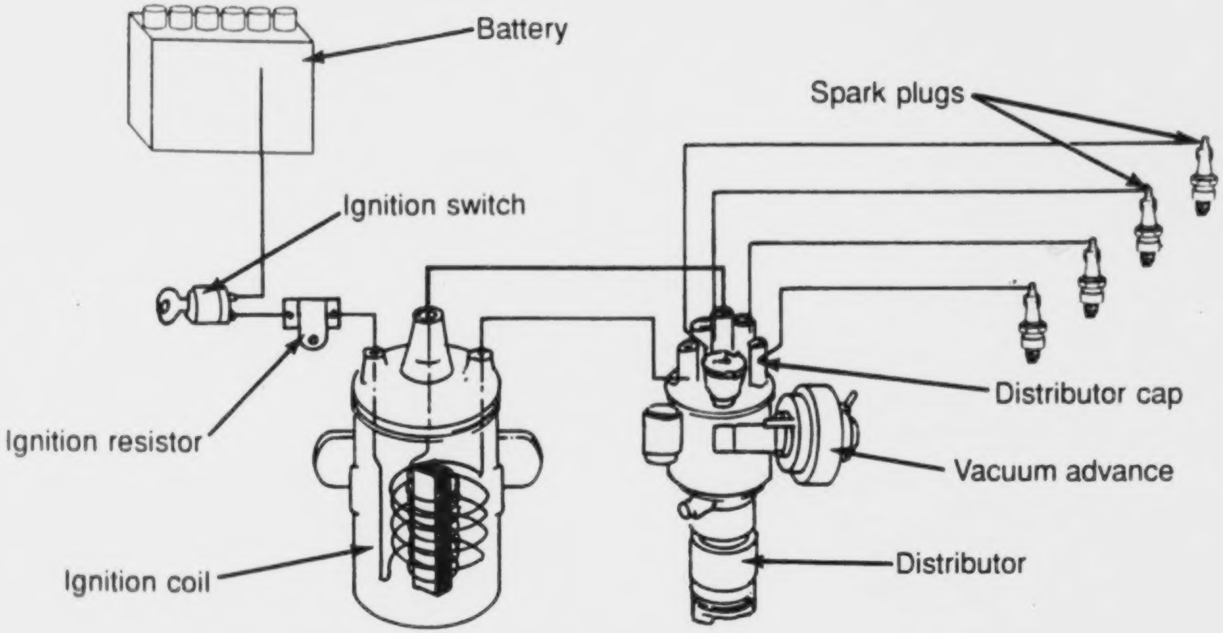
Contact Point Ignition System


Battery
Spark plugs
Ignition switch
Distributor cap
Ignition resistor
Vacuum advance
Distributor
Ignition coil

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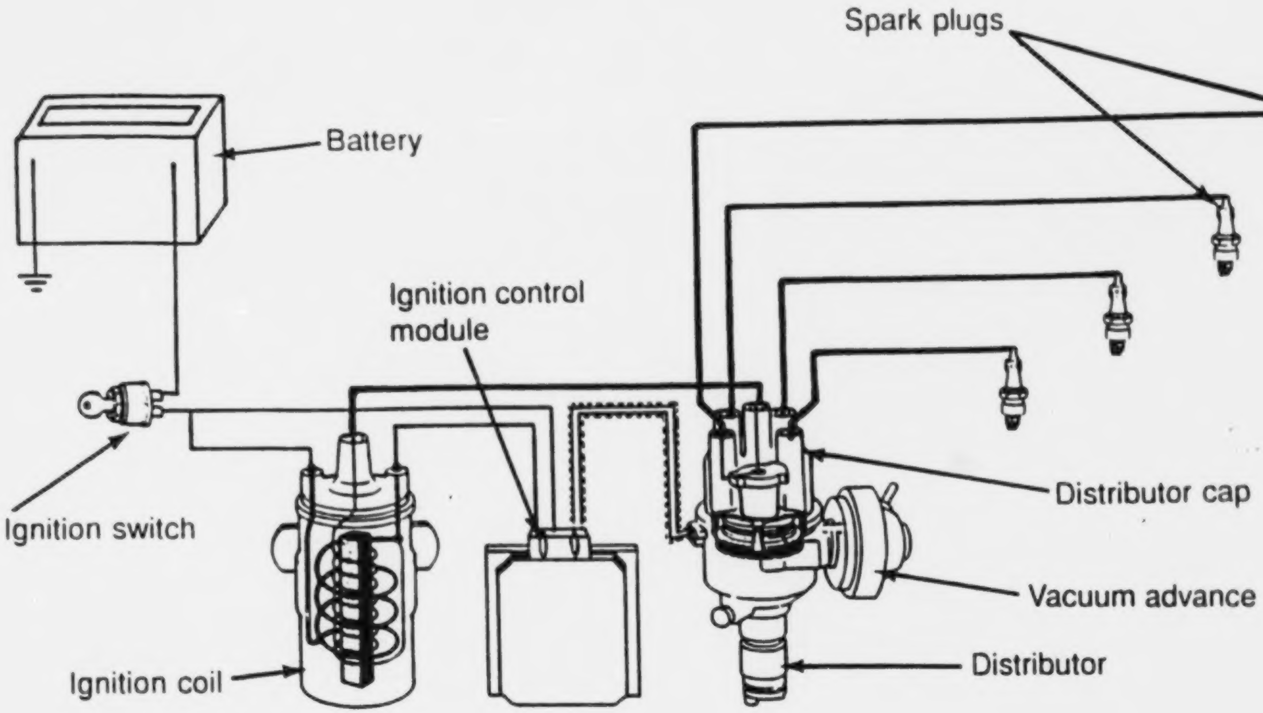
INSTRUCTOR'S RESOURCE PACKAGE · Engine Performance Specialist
TRANSPARENCY MASTER 1 - **CIMC** · 7 · 1

TM 1

Electronic Distributor Ignition System


Spark plugs
Battery
Ignition control module
Distributor cap
Ignition switch
Vacuum advance
Ignition coil
Distributor

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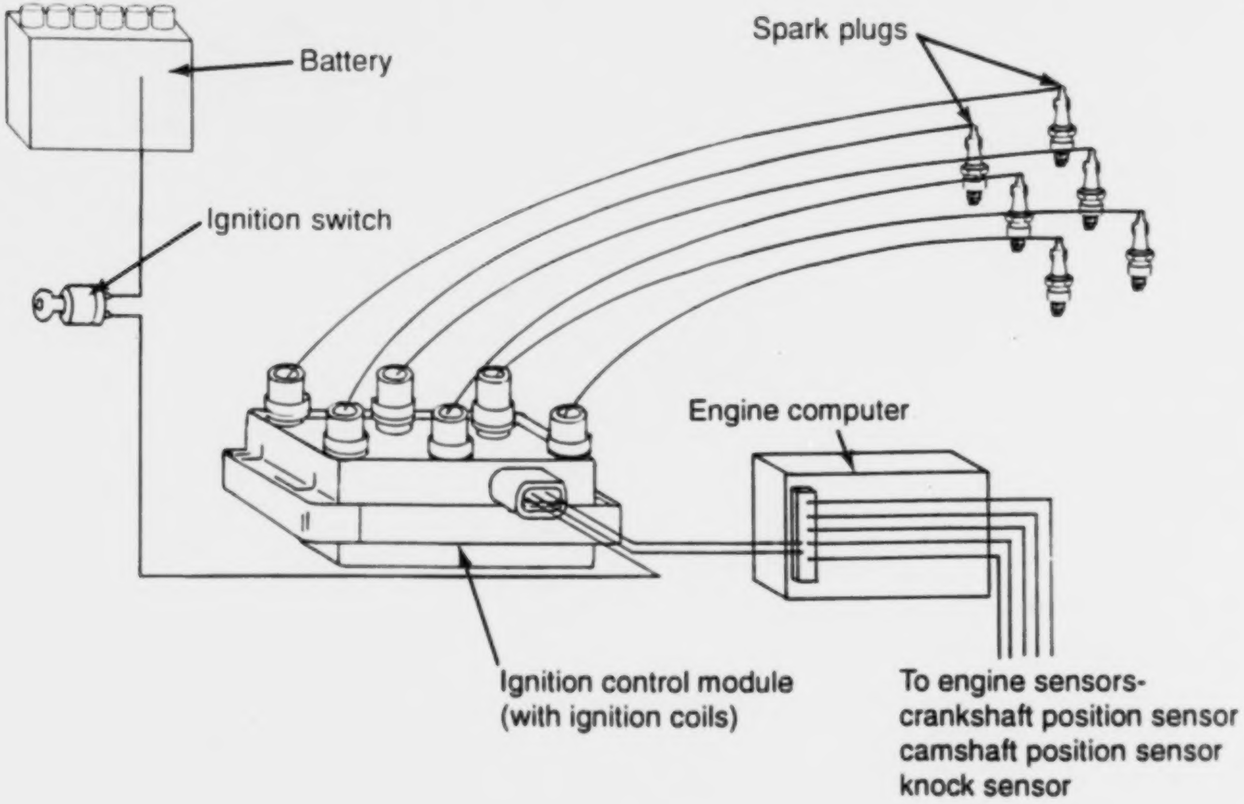
TRANSPARENCY MASTER 2 - **CIMC** · 7 · 1

TM 2

Electronic Distributorless Ignition System


Battery
Spark plugs
Ignition switch
Engine computer
Ignition control module
(with ignition coils)
To engine sensors-
crankshaft position sensor
camshaft position sensor
knock sensor

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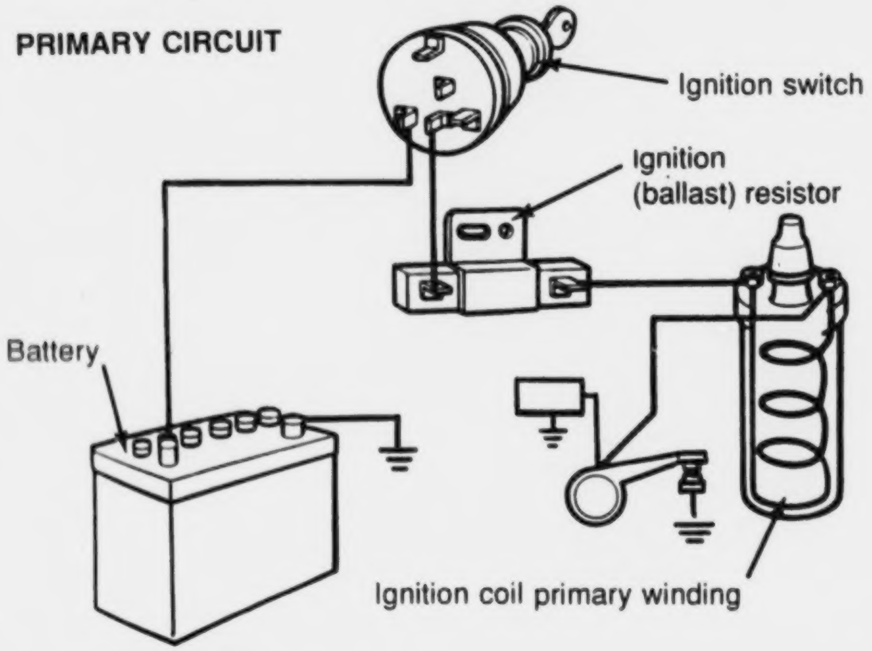
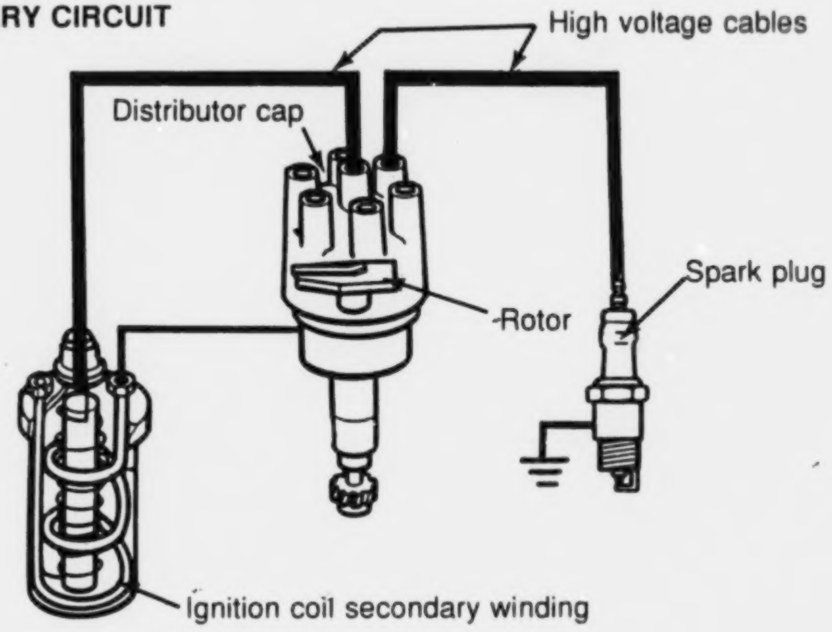
Primary/Secondary Circuits

PRIMARY CIRCUIT


Ignition switch
Ignition (ballast) resistor
Battery
Ignition coil primary winding

SECONDARY CIRCUIT


High voltage cables
Distributor cap
Spark plug
Rotor
Ignition coil secondary winding

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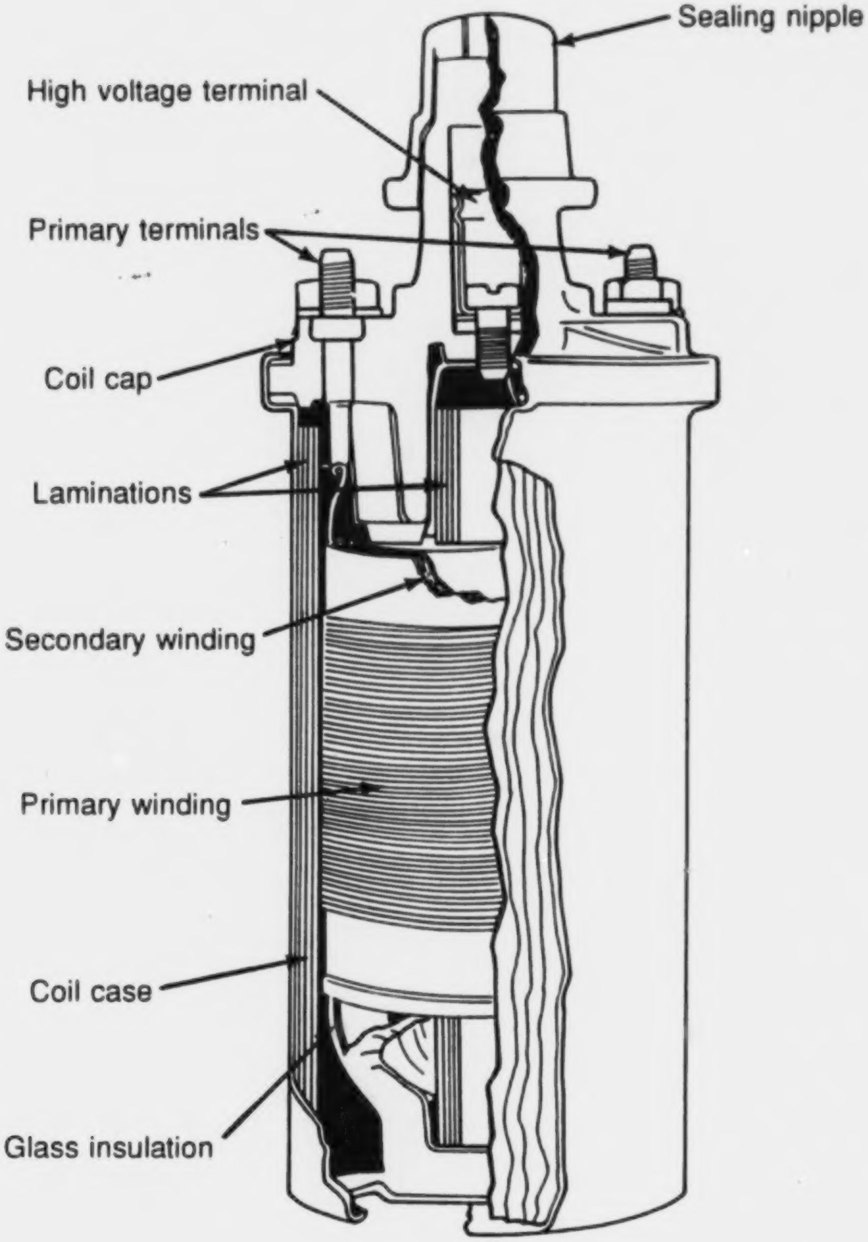
Parts of an Ignition Coil


Sealing nipple
High voltage terminal
Primary terminals
Coil cap
Laminations
Secondary winding
Primary winding
Coil case
Glass insulation

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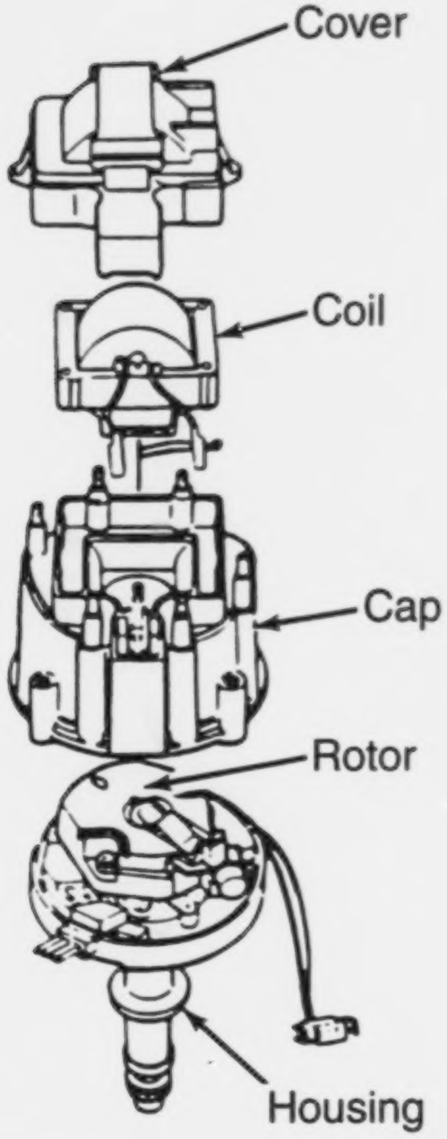
Parts of a Distributor


Cover
Coil
Cap
Rotor
Housing

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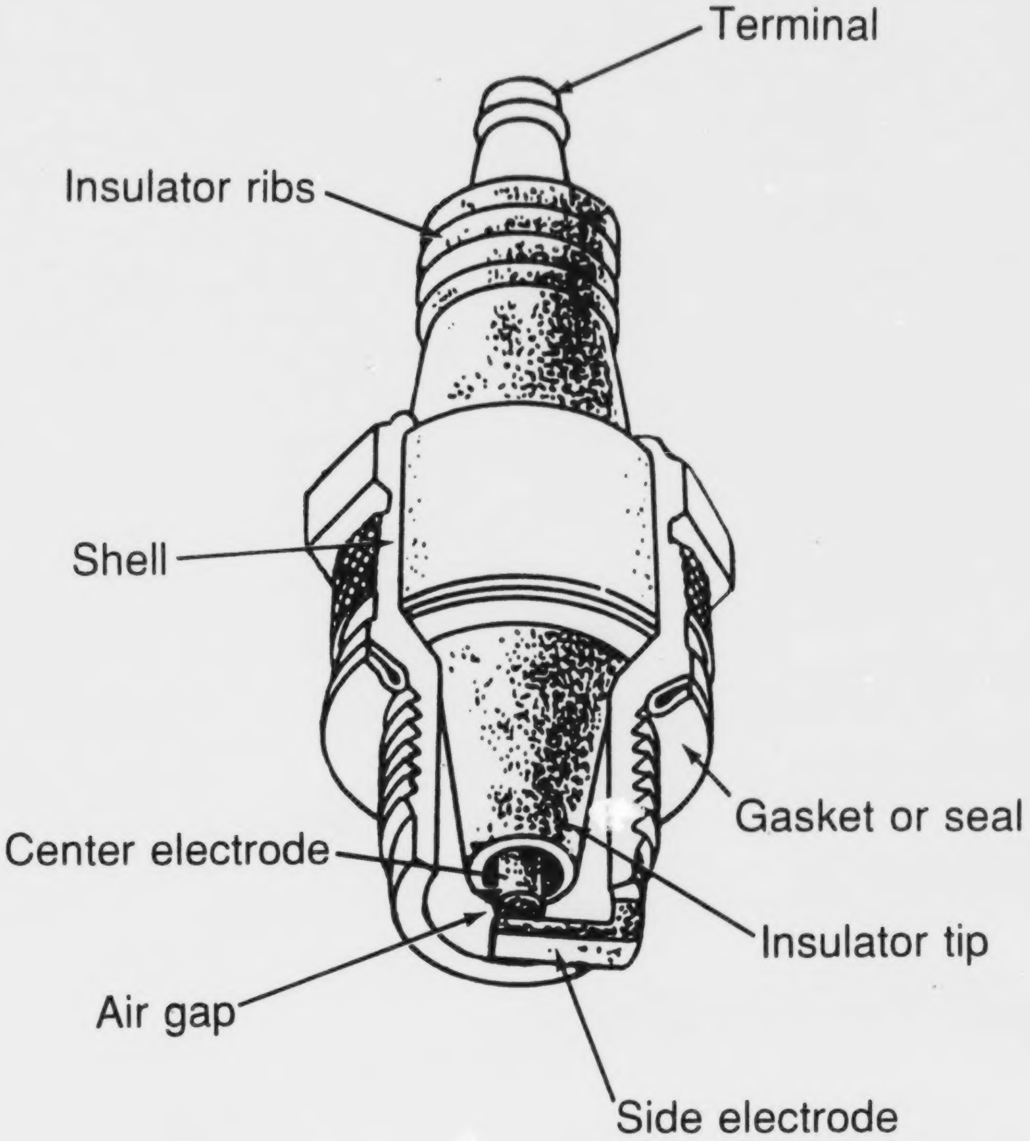
Parts of a Spark Plug


Terminal
Insulator ribs
Shell
Gasket or seal
Center electrode
Insulator tip
Air gap
Side electrode

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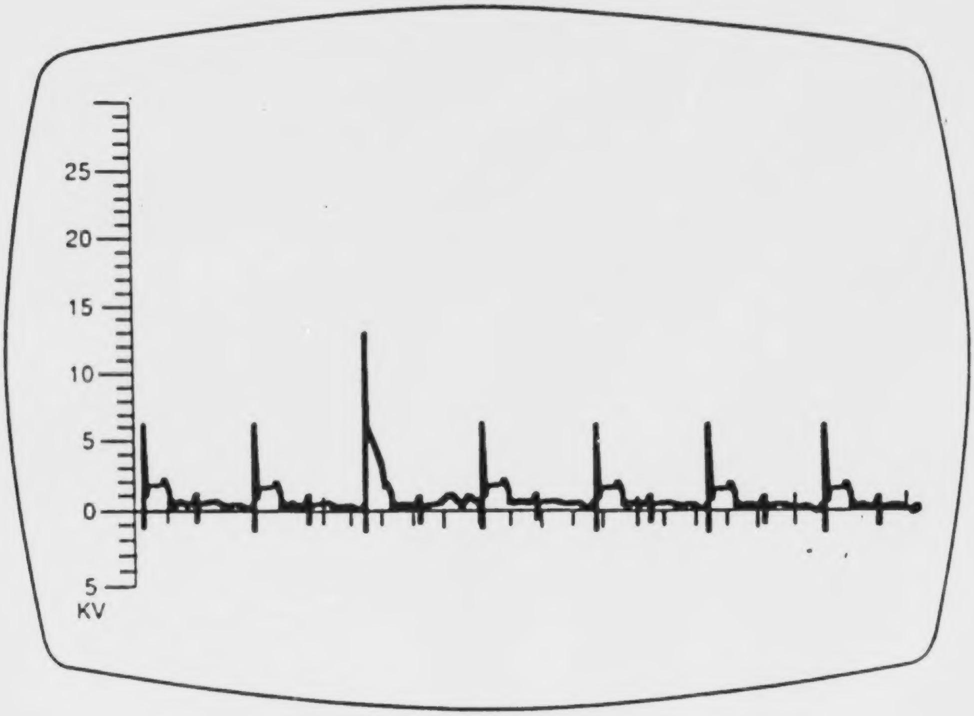
High Spark Line



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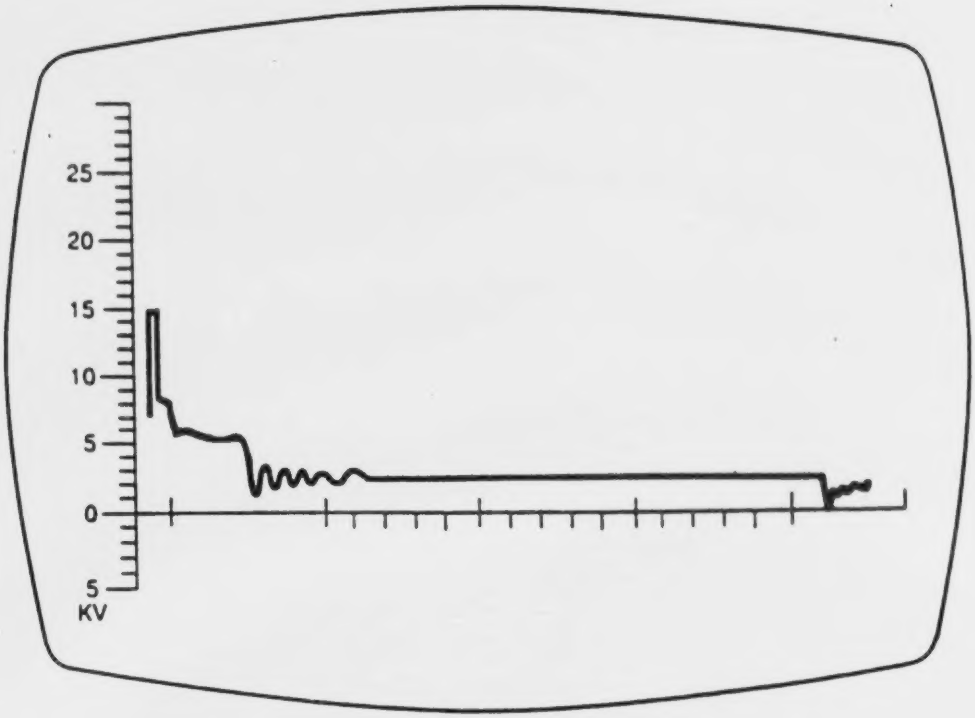
Low Spark Line



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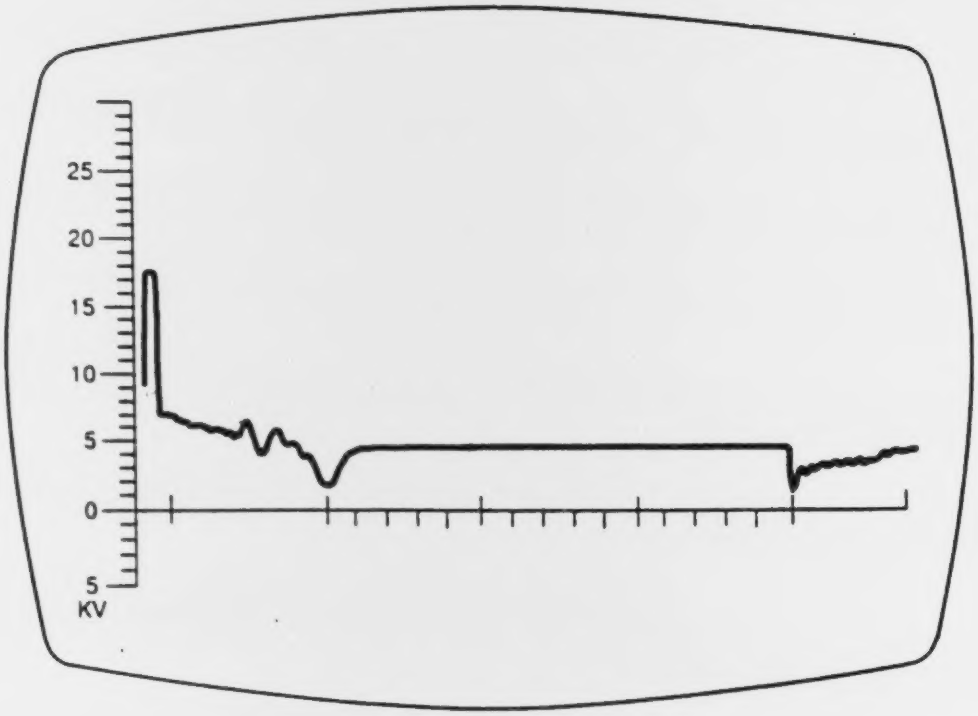
Oscillations Lost



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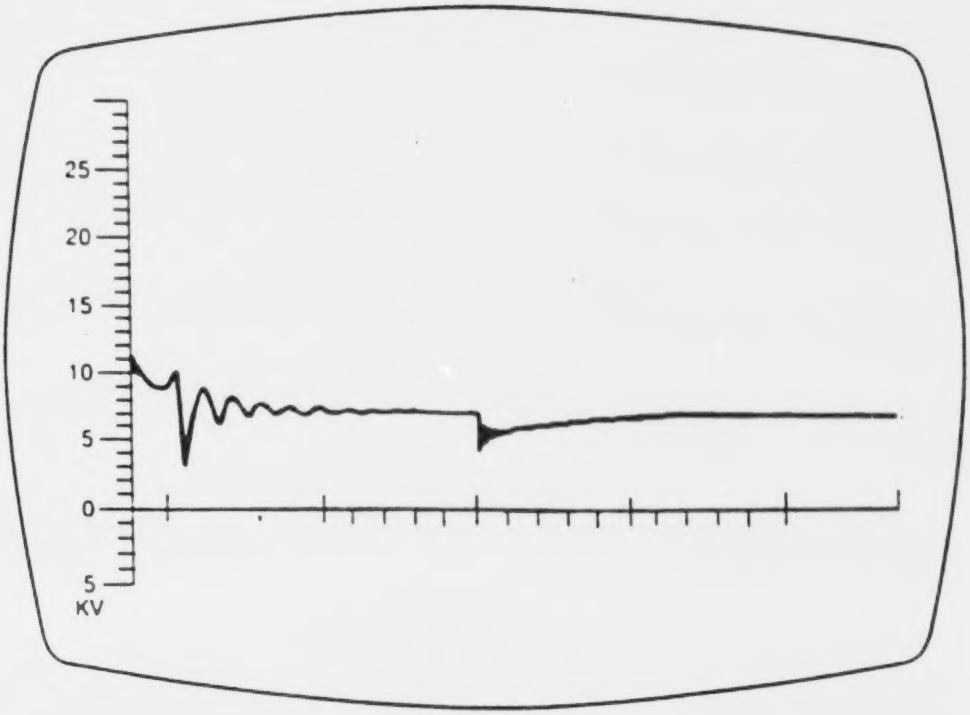
Firing Line Drops



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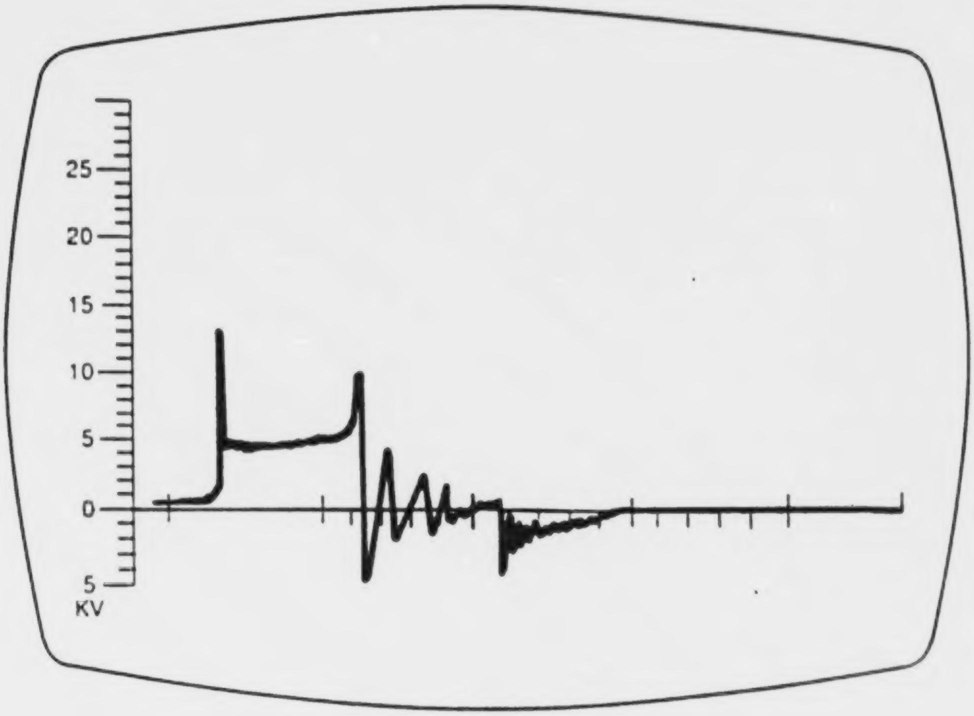
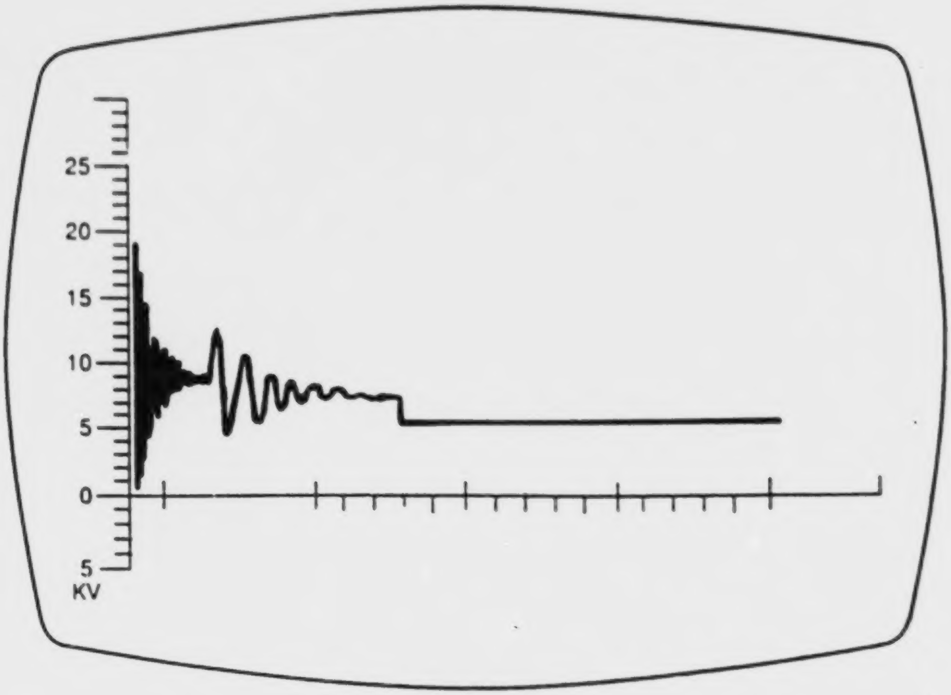
Typical Primary Scope Pattern For an Electronic Distributor Ignition



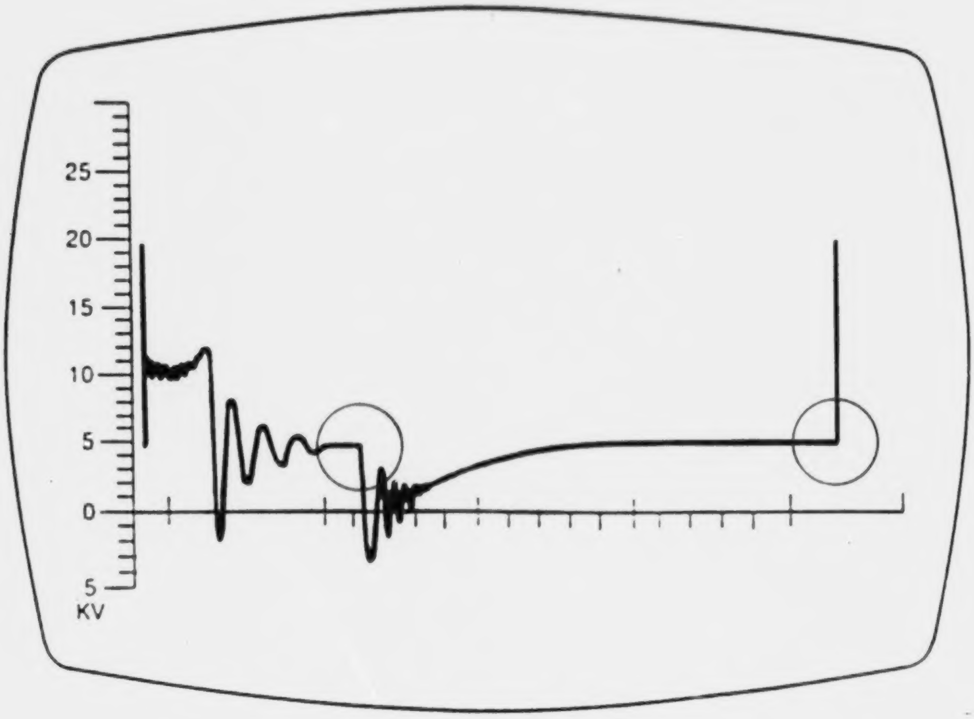
May be photocopied for student use.

Typical Primary Scope Pattern for a Contact Point Ignition



May be photocopied for student use

Oscilloscope Ignition Coil ON and OFF



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WRITTEN TEST — SERVICING IGNITION SYSTEMS — 7

Name ______________________ Date __________ Score ____

OBJECTIVE 1

State the purpose of an automotive ignition system. Write your answer in the space provided.

____

____

____

OBJECTIVE 2

Identify three types of ignition systems shown in illustrations. Write the type of ignition system in the spaces labeled A, B, & C below the illustrations following objective 3.

OBJECTIVE 3

Label ignition system components indicated on illustrations of the three types. Write the names of the components indicated on the blanks provided beneath the illustrations.

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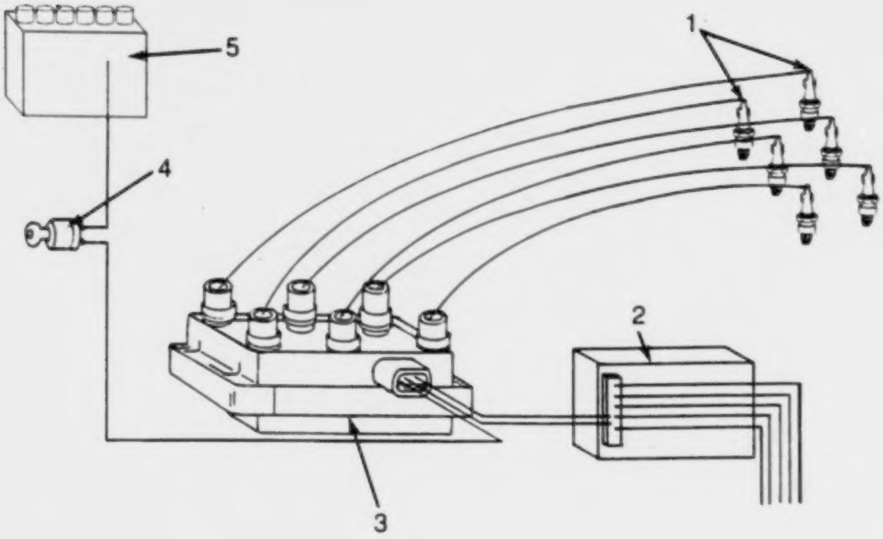

A. Type of ignition system ______________________

Names of components indicated:

1. ______________________

2. ______________________

3. ______________________

4. ______________________

5. ______________________

6. ______________________

419

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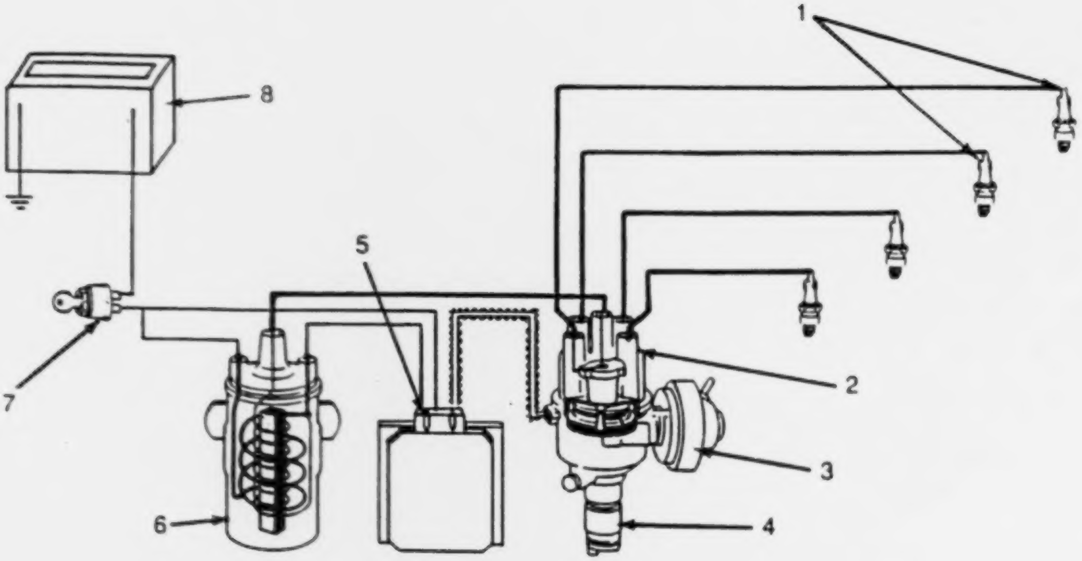

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B. Type of ignition system ______________________

Names of components indicated:

1. ______________________

2. ______________________

3. ______________________

4. ______________________

5. ______________________

6. ______________________

7. ______________________

8. ______________________

420

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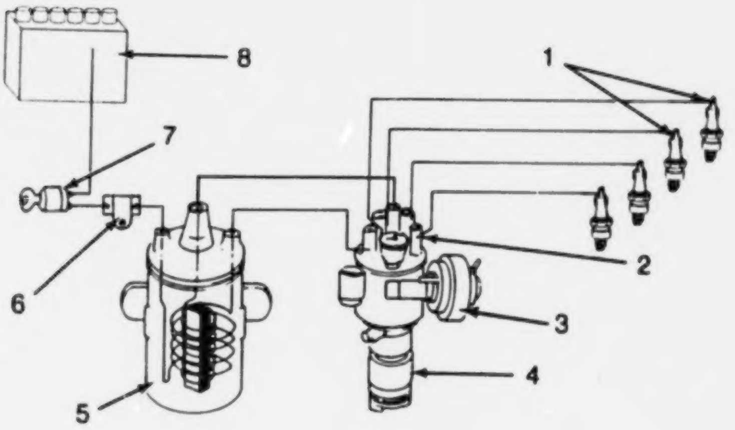

C. Type of ignition system ______________________

Names of components indicated:

1. ______________________

2. ______________________

3. ______________________

4. ______________________

5. ______________________

6. ______________________

7. ______________________

8. ______________________

OBJECTIVE 4

Match the names of ignition system components to descriptions of their functions. Write the letter of the correct term in the blank in front of the description.

A. battery
B. camshaft position sensor
C. crankshaft position sensor
D. distributor
E. distributor cap
F. engine computer
G. ignition coil

H. ignition control module
I. ignition (ballast) resistor
J. ignition switch
K. knock sensor
L. spark plug
M. vacuum advance

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____ 1. Uses electricity from the ignition coil to ignite the air-fuel mixture in the cylinder

____ 2. Advances spark timing

____ 3. Reports engine speed and the position of the #1 piston

____ 4. Reports camshaft and valve position on the # 1 piston

____ 5. Analyzes information from engine sensors, decides what changes to make, if any, and signals the control device(s)

____ 6. Provides electrical power for the vehicle

____ 7. Determines the firing order of the cylinders and directs electrical power to the correct spark plug at exactly the right time

____ 8. Increases the low voltage from the battery to the higher voltage required to create a spark at the spark plug

____ 9. An ignition system computer which receives information from various sources, analyzes that information, and uses it to ground the coil(s) at the correct instant

____ 10. Its central terminal transfers electrical power from the coil wire to the rotor; its outer terminals receive current from the rotor and transfer it to the spark plug wires

____ 11. Turns the ignition system on and off

____ 12. Reduces the voltage from the battery

____ 13. Reports engine vibration indicating the need for less spark advance

OBJECTIVE 5

Describe the operation of an electronic distributor ignition system. Write the description in the space provided.

____

____

____

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OBJECTIVE 6

Describe the operation of an electronic distributorless ignition system. Write the description in the space provided.

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OBJECTIVE 7

Compare and contrast types of ignition systems. Complete the chart in the space provided under each ignition system classification.

Similarities and Differences Between Ignition Systems

	Contact Point	Electronic Distributorless	Electronic Distributor
Number of coils			
Regulation of Spark Timing			
Maintenance			
Firing Order of Cylinders			
Purpose			

OBJECTIVE 8

State the purpose of a triggering system. Write your answer in the space provided.

____

____

____

____

____

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OBJECTIVE 9

Match the names of types of triggering systems for electronic ignition systems to descriptions of their operation. Write the letter of the correct term in the blank in front of the description.

A. Hall effect
B. magnetic pickup
C. photodiode

____ 1. Senses the light flashes produced by a light-emitting diode and spinning trigger blades and sends a signal to the ignition control unit

____ 2. Uses a semiconductor sensor to detect rotation of trigger blades or shutters and sends a signal to the ignition control unit

____ 3. Uses a coil magnetic type sensor to detect the rotation of a toothed wheel and sends a signal to the ignition control unit

OBJECTIVE 10

State the purpose of an ignition coil. Write your answer in the space provided.

OBJECTIVE 11

State the main difference between the primary circuit and the secondary circuit. Write your answer in the space provided.

OBJECTIVE 12

Distinguish between primary and secondary circuit components on an illustration. Put a "P" by the names of components that are in the primary circuit and put an "S" by the names of the components that are in the secondary circuit.

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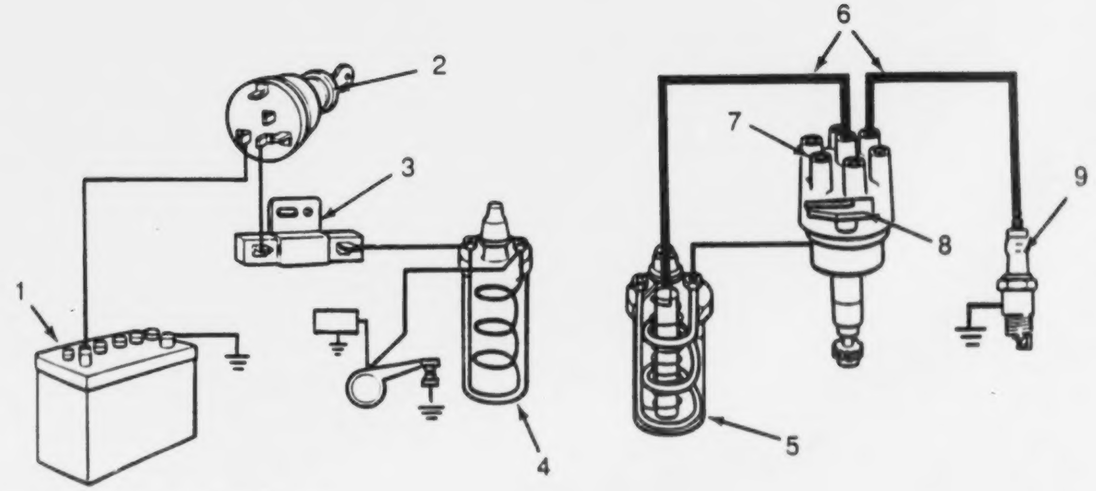

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____ 1. battery

____ 2. ignition switch

____ 3. ignition (ballast) resistor

____ 4. ignition coil primary winding

____ 5. ignition coil secondary winding

____ 6. high voltage cables

____ 7. distributor cap

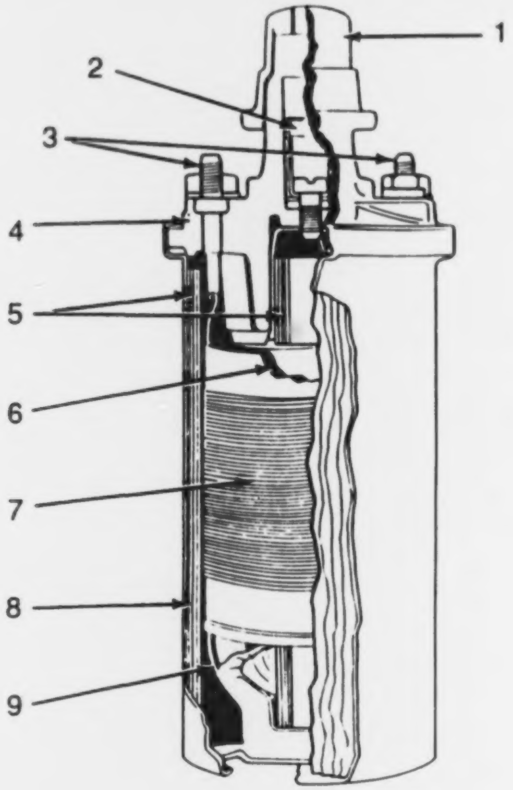
____ 8. rotor

____ 9. spark plug

May be photocopied for student use.

OBJECTIVE 13

Match the names of the parts of an ignition coil to an illustration. Write the letter of the component indicated in the correct blank.



_____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

_____ 6.

_____ 7.

_____ 8.

_____ 9.

A. coil cap

B. coil case

C. glass insulation

D. high-voltage terminal

E. laminations

F. primary terminals

G. primary winding

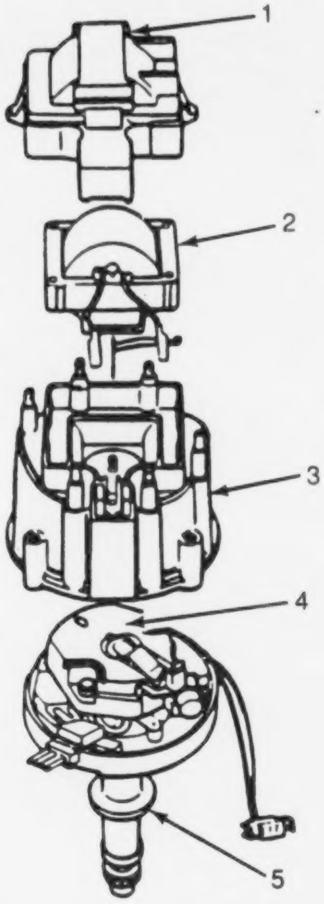
H. sealing nipple

I. secondary winding

May be photocopied for student use.

OBJECTIVE 14

Match the names of the parts of a distributor to an illustration. Write the letter of the component indicated in the correct blank.



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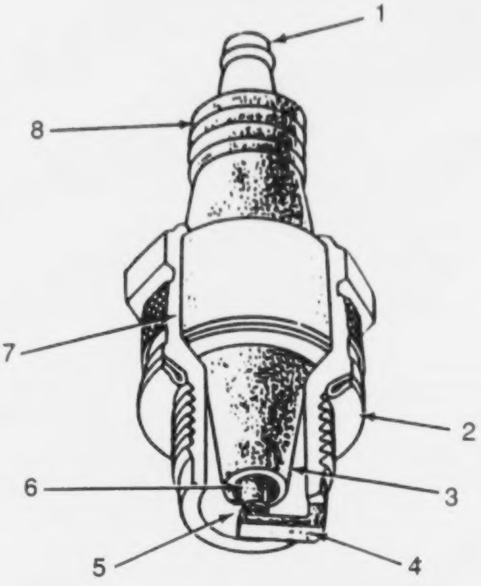
_____	1.	A.	cap
_____	2.	B.	coil
_____	3.	C.	cover
_____	4.	D.	housing
_____	5.	E.	rotor

OBJECTIVE 15

Label the parts of a spark plug indicated on an illustration. Write the name of the part indicated in the corresponding blank.



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1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

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5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

OBJECTIVE 16

Match the names of types of spark plugs to statements describing their qualities. Write the letter of the correct answer in the blank to the left of the description.

A. cold
B. hot
C. multiple electrode
D. narrow gap
E. resistor
F. single electrode
G. wide gap

_____ 1. Refers to a spark plug constructed with a single center electrode and 2-6 side electrodes

_____ 2. A multiple electrode spark plug requiring a narrow jump and, therefore, less voltage from the center electrode to the side electrodes

_____ 3. Has a short insulator tip and operates at a cooler temperature preventing overheating and preignition in engines that operate at high speeds

_____ 4. Refers to a spark plug constructed with a single center electrode and a single side electrode

_____ 5. A multiple electrode spark plug requiring a wide jump from the center electrode to the side electrodes; this type burns hotter which helps reduce emissions

_____ 6. Will not cause noise or static on the vehicle's radio as spark plugs not of this type can

_____ 7. Has a long insulator tip and a hot operating temperature which allows it to burn off deposits, providing a self-cleaning action

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OBJECTIVE 17

Match the names of secondary pattern oscilloscope tests to the ignition system condition or function monitored by the test. Write the letter of the correct answer in the blank to the left of the condition or function.

A. secondary wire insulation test
B. secondary wire resistance test
C. spark test

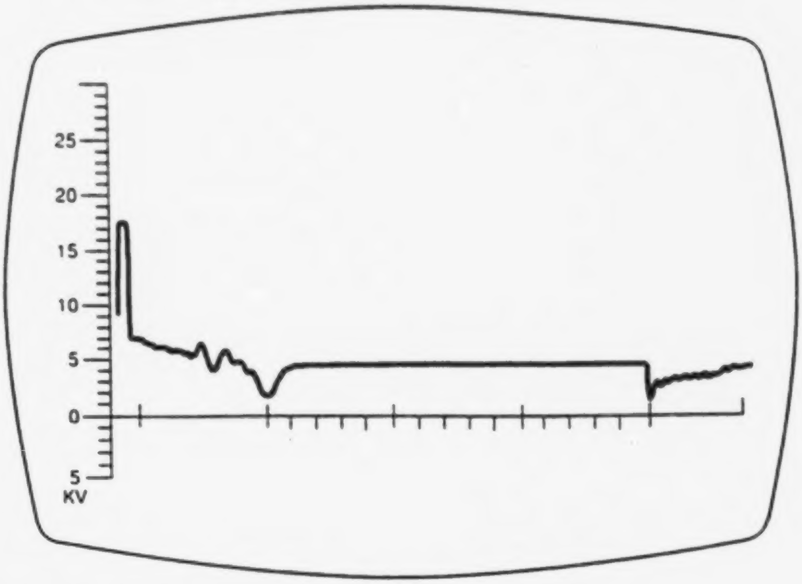
____ 1. Evaluates the condition of the coil wire and the spark plug wires

____ 2. Determines whether voltage is being lost through poor insulation, a break in the wire, or other cause

____ 3. Determines if the high voltage surges from the ignition coil are being transferred to the spark plugs

OBJECTIVE 18

Identify abnormal oscilloscope patterns shown in illustrations. Write the type of oscilloscope pattern shown in the blank below the illustration.



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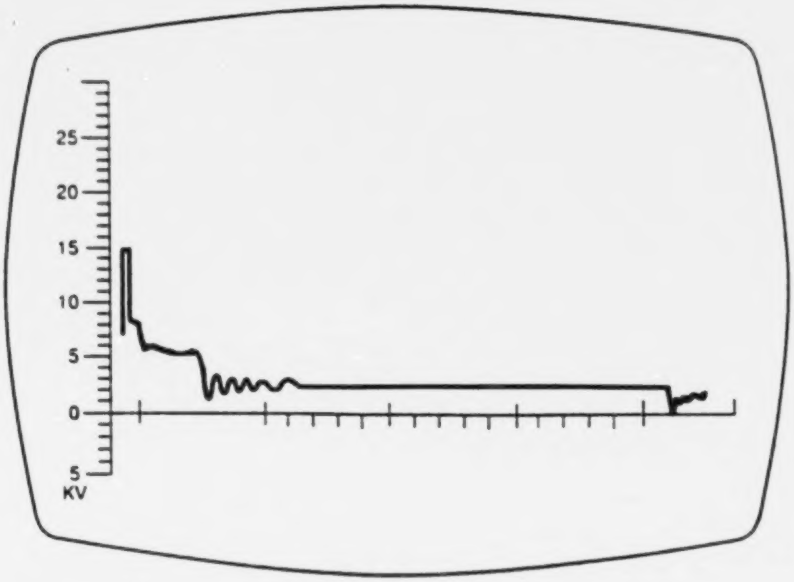
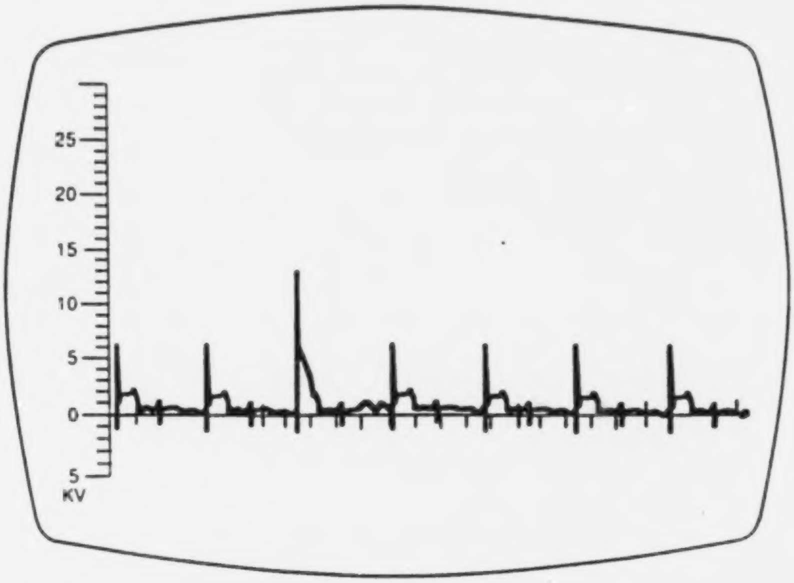
1. Type of pattern: ______________________________

May be photocopied for student use.



Used with permission of the Allen Group, Inc.

2. Type of pattern: ______________________________



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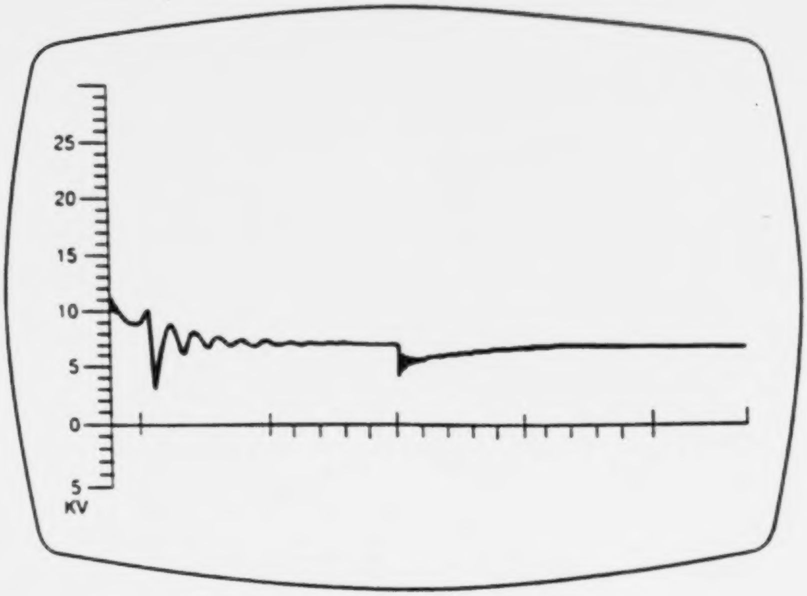
3. Type of pattern: ______________________________

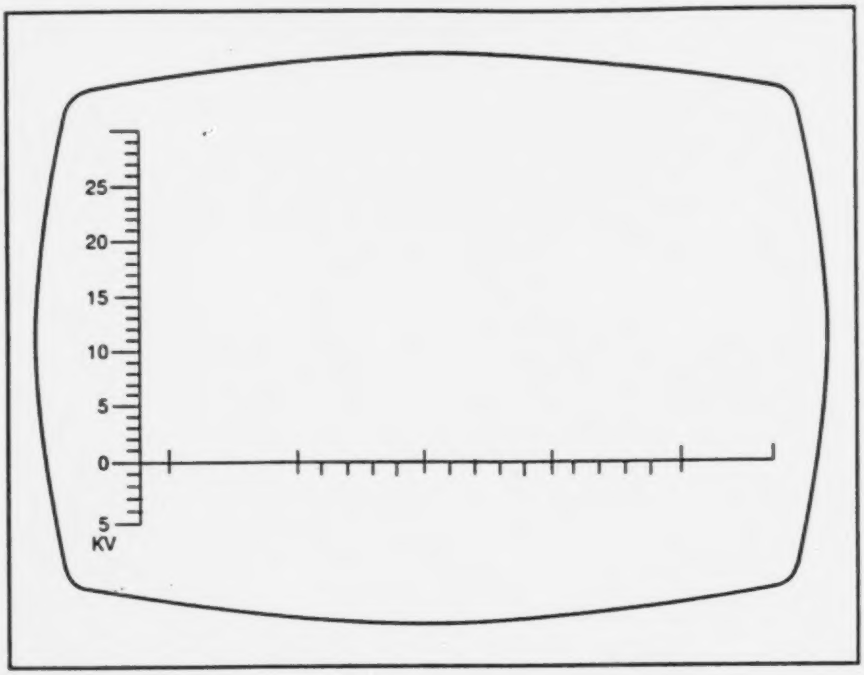
May be photocopied for student use.



4. Type of pattern: ______________________

OBJECTIVE 19

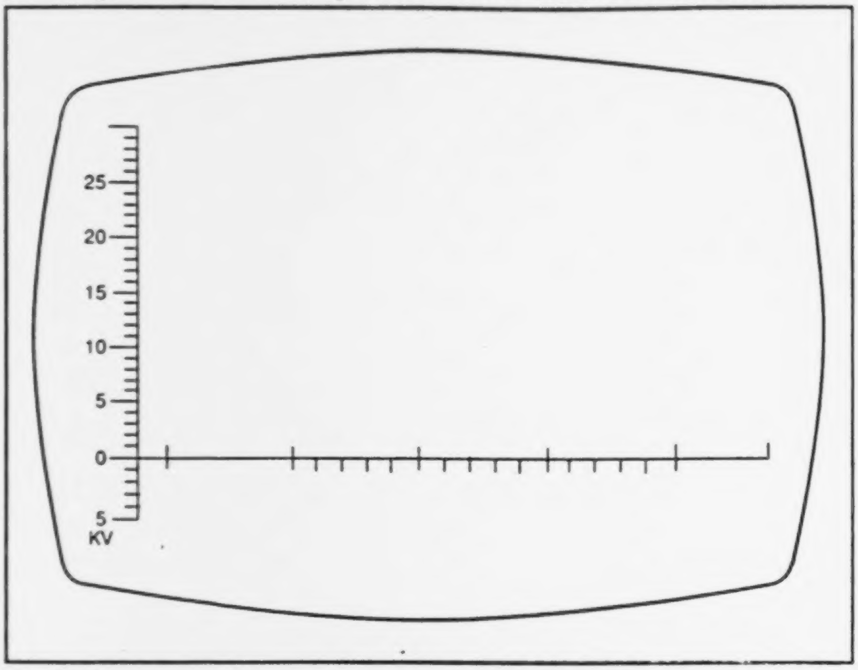
Draw a typical primary oscilloscope pattern for an electronic distributor ignition. Draw the pattern on the blank screen below.



May be photocopied for student use.

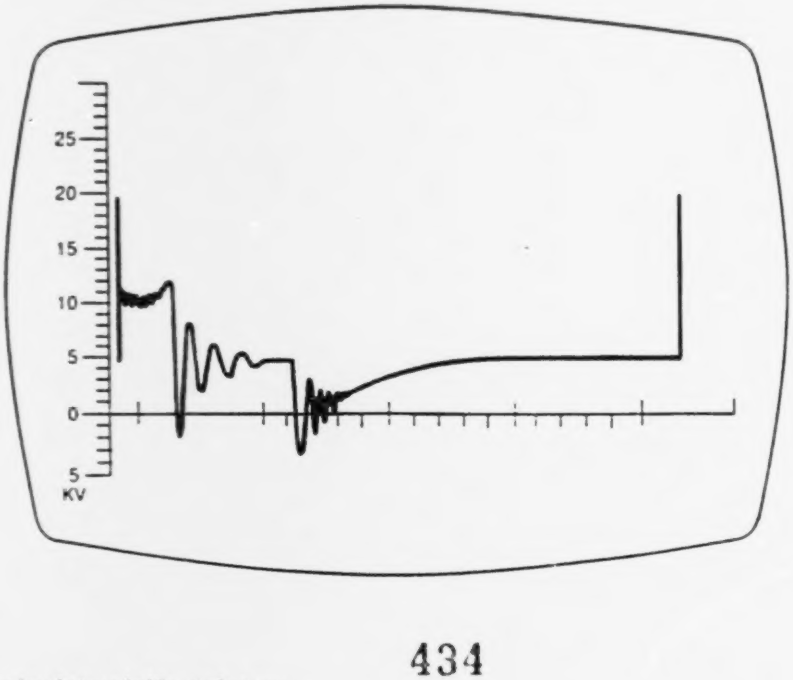
OBJECTIVE 20

Draw a typical primary oscilloscope pattern for a contact point ignition. Draw the pattern on the blank screen below.



OBJECTIVE 21

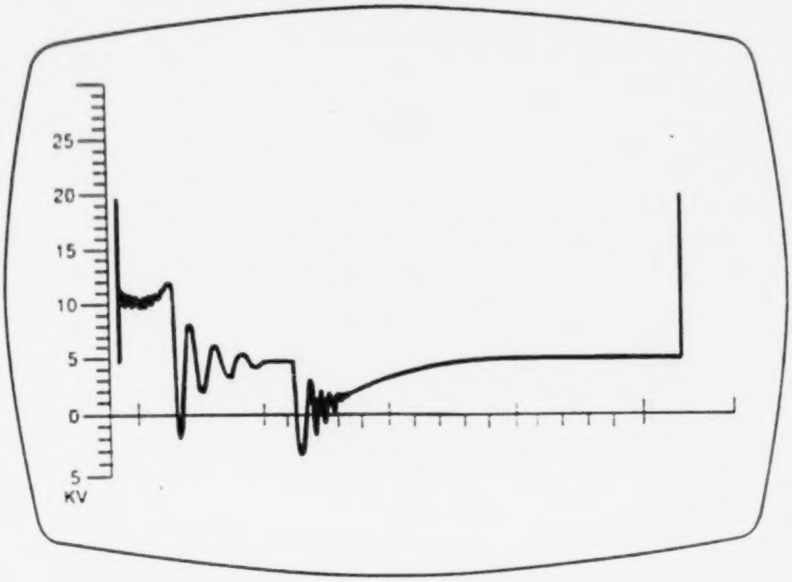
Circle the area of an oscilloscope pattern which corresponds to ignition coil ON. Circle the area on the sample pattern below.



May be photocopied for student use.

OBJECTIVE 22

Circle the areas of an oscilloscope pattern which correspond to oscilloscope ignition coil OFF. Circle the area on the sample screen below.



OBJECTIVE 23 **Evaluated on Job Sheet 1.**

OBJECTIVE 24 **Evaluated on Job Sheet 2.**

OBJECTIVE 25 **Evaluated on Job Sheet 3.**

OBJECTIVE 26 **Evaluated on Job Sheet 4.**

OBJECTIVE 27 **Evaluated on Job Sheet 5.**

OBJECTIVE 28 **Evaluated on Job Sheet 6.**

May be photocopied for student use.

OBJECTIVE 29 **State the purpose of a spark timing system.** Write your answer in the space provided.

____

____

____

OBJECTIVE 30 **Match the names of types of spark timing systems to descriptions of their operation.** Write the letter of the correct answer in the blank to the left of the description.

A. electronic spark advance
B. mechanical centrifugal
C. vacuum advance

____ 1. Vacuum operated, it bases its timing action on the amount of engine vacuum in the intake manifold.

____ 2. Computer operated, it bases its timing action on the readings it receives from the crank sensor and/or the cam sensor, as well as other sensors.

____ 3. Spring operated, it bases its timing action on engine rpms.

OBJECTIVE 31 **Match the names of types of ignition systems with the names of the spark timing systems used with them.** Write the letters of the spark timing systems used with the ignition system on the blank line to the left of the ignition system. Each type of ignition system may use more than one type of spark timing system.

A. electronic spark advance
B. mechanical centrifugal
C. vacuum advance

________1. Electronic distributorless ignition system

________2. Contact point ignition system

________3. Electronic distributor ignition system

OBJECTIVE 32 **Evaluated on Job Sheet 7.**

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OBJECTIVE 33	**Evaluated on Job Sheet 8.**
OBJECTIVE 34	**Evaluated on Job Sheet 9.**
OBJECTIVE 35	**Evaluated on Job Sheet 10.**
OBJECTIVE 36	**Evaluated on Job Sheet 11.**
OBJECTIVE 37	**Evaluated on the Assignment Sheet.**

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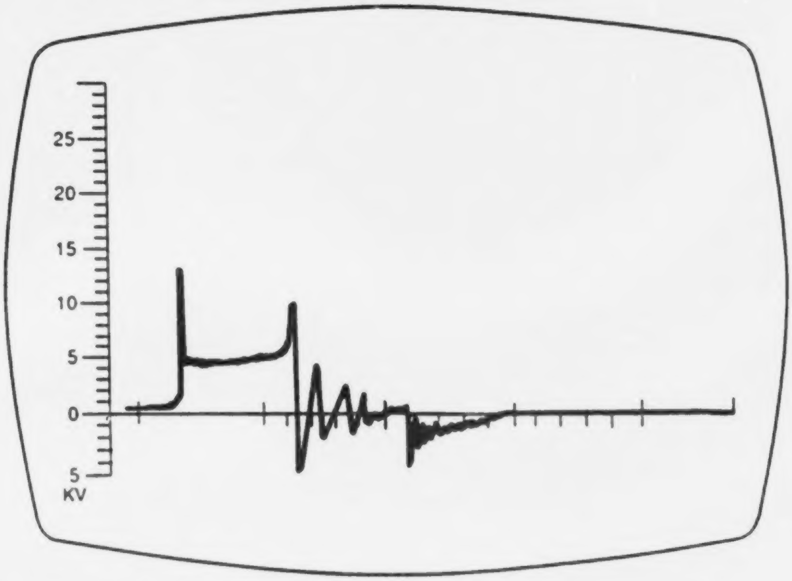
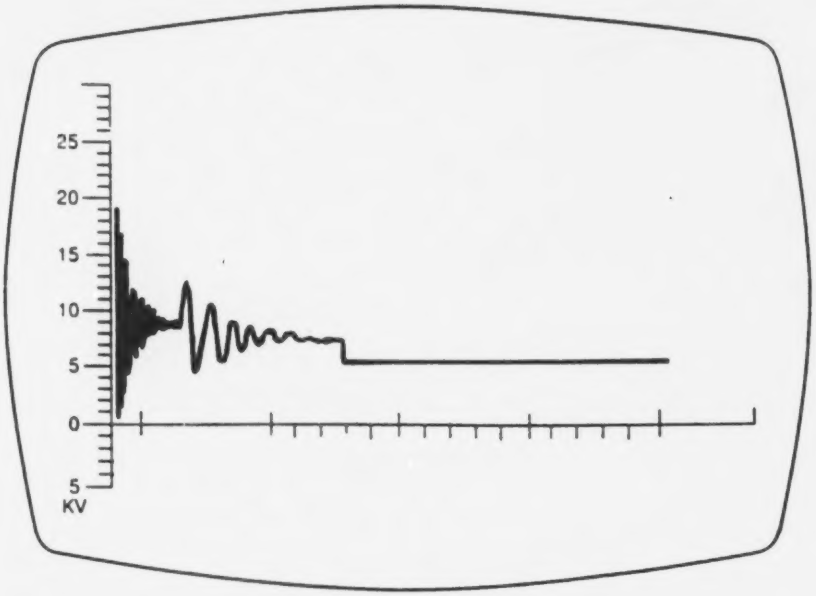
Normal Oscilloscope Patterns

- **Electronic distributor ignition system**



- **Contact point ignition system**



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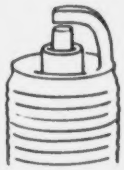
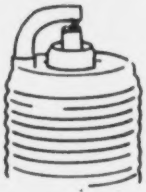
HANDOUT 2 | *SERVICING IGNITION SYSTEMS* | 7

Spark Plug Conditions



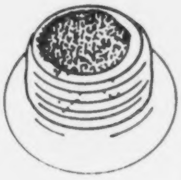
NORMAL
Brown to grayish tan color and slight electrode wear. Correct heat range for engine and operating conditions.

RECOMMENDATION: Service and reinstall. Replace if over recommended mileage.



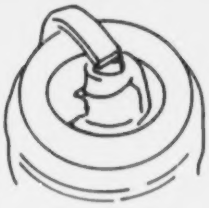
GAP BRIDGED
Deposits in the fuel have formed a bridge between the electrodes, eliminating the air gap, and grounding the plug.

RECOMMENDATION: Sometimes plug can be serviced and reinstalled. Check for excess additives in fuel.



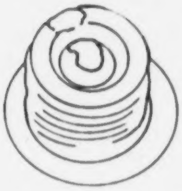
CARBON DEPOSITS
Dry soot, frequently caused by use of spark plug with incorrect heat range.

RECOMMENDATION: Carbon deposits indicate rich mixture or weak ignition. Check for clogged air cleaner, high float level, sticky choke, or worn contact points. Hotter plugs will provide additional fouling protection.



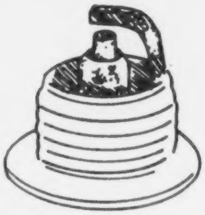
DETONATION
Insulator has cracked and broken away as a result of the shock waves created by detonation.

RECOMMENDATION: Cause of detonation must be found and corrected. Check for use of low-octane fuel, improper air-fuel mixture, incorrect ignition timing, overheating, and increased octane requirement in the engine.



PREIGNITION
Improper heat range, incorrect ignition timing, lean air-fuel mixture, or hot spots in combustion chamber has caused melted electrodes. Center electrode generally melts first and ground electrode follows. Normally, insulators are white, but may be dirty due to misfiring or flying debris in combustion chamber.

RECOMMENDATION: Check for correct plug heat range, over-advanced ignition timing, lean air-fuel mixture, clogged cooling system, leaking intake manifold, and lack of lubrication.



SPLASHED DEPOSITS
Spotted deposits. Occurs shortly after long-delayed tuneup. After a long period of misfiring, deposits may be loosened when normal combustion temperatures are restored by tuneup. During a high-speed run, these materials shed off the piston and head and are thrown against the hot insulator.

RECOMMENDATION: Clean and service the plugs properly and reinstall.

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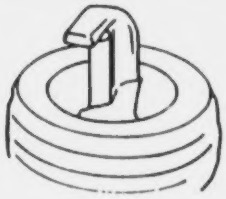
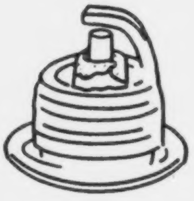
Spark Plug Conditions (continued)



MECHANICAL DAMAGE

Something such as a foreign object in cylinder, or the piston, has struck the ground electrode. It has been forced into the center electrode, which has bent and broken off the insulator.

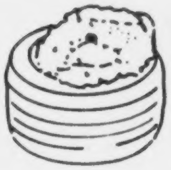
RECOMMENDATION: Check that plug has the correct reach for the engine, that the gap was set properly, and that no foreign object remains in cylinder.



HIGH-TEMPERATURE GLAZING

Insulator has yellowish, varnish-like color. Indicates combustion chamber temperatures have risen suddenly during hard, fast acceleration. Normal deposits do not get a chance to blow off. Instead, they melt to form a conductive coating.

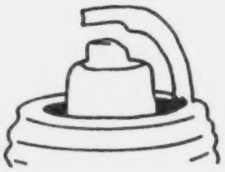
RECOMMENDATION: If condition recurs, use plug type one step colder.



ASH DEPOSITS

Poor oil control, use of improper oil, or use of improper additives in fuel or oil has caused an accumulation of ash which completely covers the electrodes.

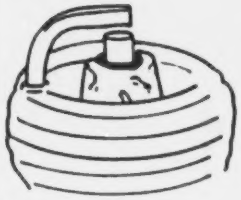
RECOMMENDATION: Eliminate source of ash. Install new spark plugs.



WORN

Center electrode worn away too much to be filed flat.

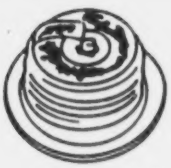
RECOMMENDATION: Replace with new spark plugs of proper heat range.



OVERHEATED

Blistered, white insulator, eroded electrodes and absence of deposits.

RECOMMENDATION: Check for correct plug heat range, over-advanced ignition timing, low coolant level or restricted flow, lean air-fuel mixture, leaking intake manifold, sticking valves, and if vehicle is driven at high speeds most of the time.



OIL DEPOSITS

Oily coating.

RECOMMENDATION: Caused by poor oil control. Oil is leaking past worn valve guides or piston rings into the combustion chamber. Hotter spark plug may temporarily relieve problem, but correct the cause with necessary repairs.

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No-Starting, Hard Starting, and Engine Misfire Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine cranks normally but fails to start.	Damaged armature (trigger wheel, reluctor) or sensor	Replace damaged part.
	Defective distributor cap or rotor	Replace defective part.
	Primary wiring connectors not fully engaged	Clean, firmly seat connectors.
	No voltage to ignition system	Check battery, ignition switch, wiring.
	Ignition coil open or shorted	Test coil, replace if defective.
	Faulty electronic control unit	Replace.
Engine backfires but fails to start.	Spark plug cables not connected in firing order	Reconnect cables correctly.
	Faulty distributor cap — leak across carbon paths	Replace cap.
	Moisture in distributor cap	Dry cap.
	Incorrect timing	Check and adjust ignition or mechanical timing.
Engine runs but misses — does not run smoothly.	Defective spark plug cables	Replace cables.
	Spark plugs fouled or faulty	Clean and regap or replace.
	Distributor cap or rotor faulty	Replace affected part.
	Bad connections	Clean, tighten.

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No-Starting, Hard Starting, and Engine Misfire Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine runs but misses—does not run smoothly. (continued)	High voltage leak	Check distributor cap, rotor, and cables.
	Defective advance mechanism	Check advances, repair or replace distributor or advance mechanism.
	Defective (weak) coil	Replace coil.
Engine runs, but backfires.	Ignition cross-firing	Check high voltage cables, distributor cap, and rotor for leakage paths.
	Ignition timing off	Re-time.
	Defective air injection system	Check and repair or replace system.
	Spark plugs of wrong heat range	Install correct plugs.
Engine overheats.	Late ignition timing	Re-time.
Engine lacks power.	Ignition timing off	Re-time.
Engine detonates or pings on acceleration.	Improper timing	Time ignition.
	Carbon buildup in cylinders	Service engine.
	Defective advance mechanism	Check advances, repair or replace distributor or advance mechanism.
	Spark plugs of wrong heat range	Install correct plugs.
Engine detonates or pings during cruise.	Faulty EGR valve	Service EGR valve.
Engine runs on.	Idle stop solenoid out of adjustment or defective	Readjust, replace as necessary.
	Air-fuel mixture too rich	Adjust float level.

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No-Starting, Hard Starting, and Engine Misfire Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine runs on.	Engine overheating	Re-time.
	Advanced timing	Re-time ignition.
	Hot spots in combustion chambers	Service engine.

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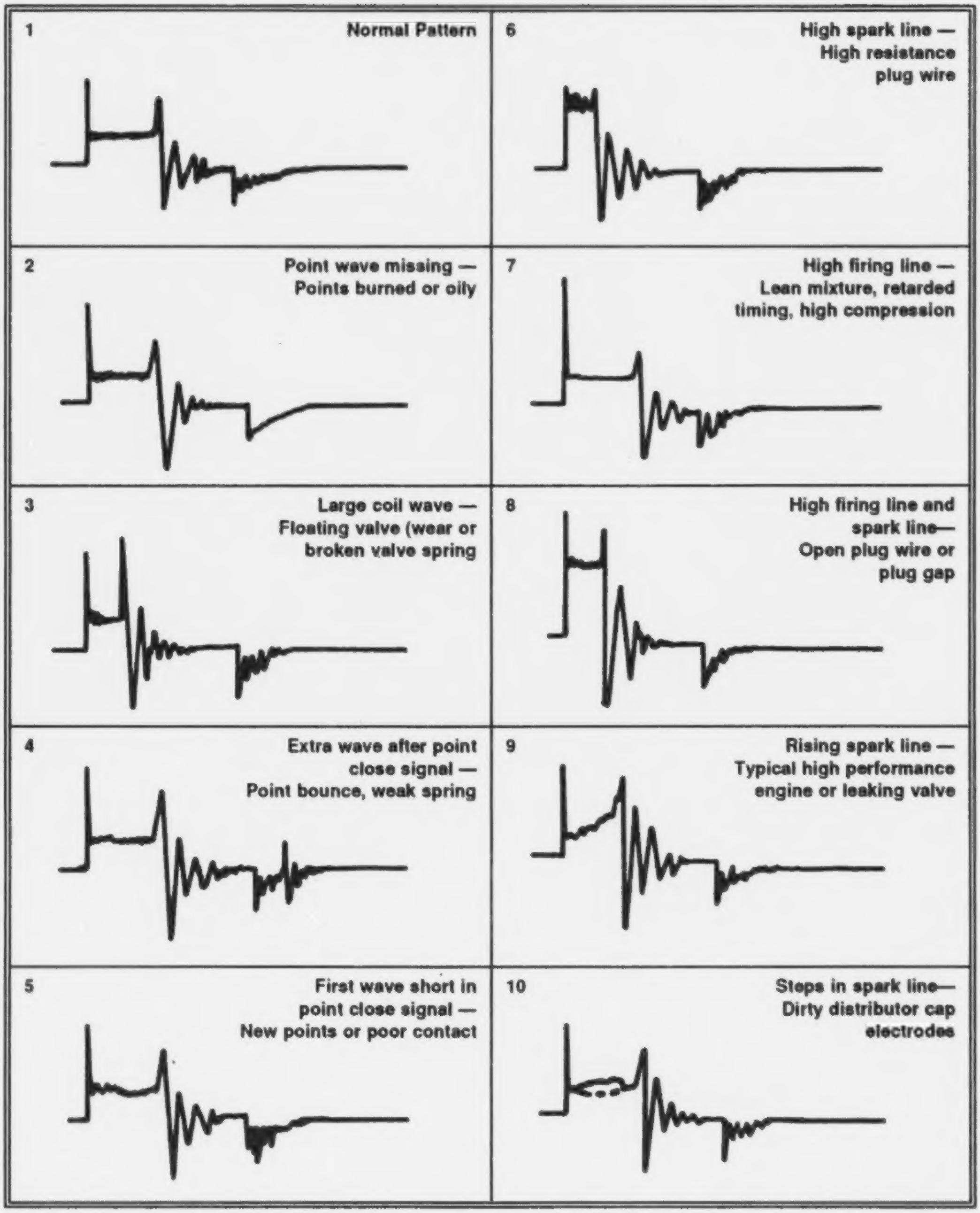
Oscilloscope Patterns Diagnosis Chart



1 Normal Pattern

2 Point wave missing — Points burned or oily

3 Large coil wave — Floating valve (wear or broken valve spring

4 Extra wave after point close signal — Point bounce, weak spring

5 First wave short in point close signal — New points or poor contact

6 High spark line — High resistance plug wire

7 High firing line — Lean mixture, retarded timing, high compression

8 High firing line and spark line— Open plug wire or plug gap

9 Rising spark line — Typical high performance engine or leaking valve

10 Steps in spark line— Dirty distributor cap electrodes

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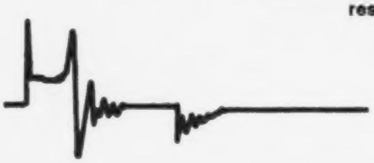
Oscilloscope Patterns Diagnosis Chart (continued)

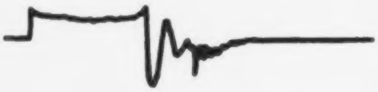
11

**Short spark line —
Weak coil or primary
resistance**



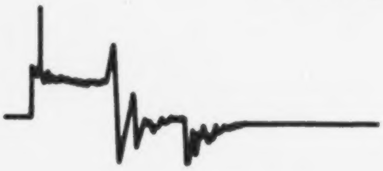
12

**Short firing line —
Plug gap closed or
plug wire grounded**



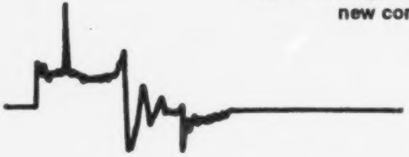
13

**Late firing line —
Points arcing slightly**



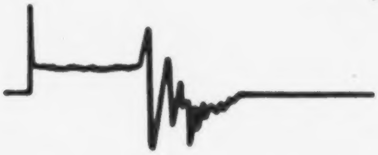
14

**Late firing line —
Points arcing, may need
new condenser**



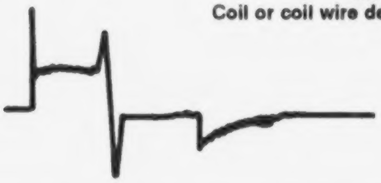
14

**Long spark line —
Charging voltage
too high**



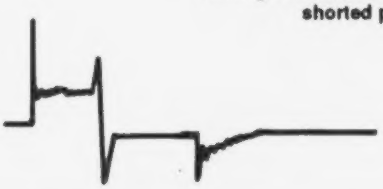
15

**Coil and point wave
missing —
Coil or coil wire defective**



16

**Coil wave missing —
Leaking condenser, may be
shorted primary**



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LAP
SHEET

SERVICING FUEL DELIVERY SYSTEMS

8

Name ______________________________

Check the blank as you complete each step.

1. **Take**	____	the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read**	____	the introduction, unit objective, and specific objectives.
3. **Do**	____	the focus assignments.
4. **Stop**	____	and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study**	____	the Information Sheet, objectives 1, 2, and 3.
6. **Ask**	____	your instructor to show you the three types of fuel delivery systems on actual vehicles.
7. **Study**	____	the Information Sheet, objective 4.
8. **Ask**	____	your instructor to explain how the three types of fuel delivery systems shown in Figures 1, 2, and 3 operate.
9. **Study**	____	the Information Sheet, objectives 5 and 6.
Optional: Make	____	two sets of cards, one set with the names of fuel delivery system parts, and the other set with descriptions of their functions. See if you can match the cards.
10. **Study**	____	the introduction to Job Sheet 1.
11. **Ask**	____	your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

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12. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

13. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

14. **Study** ____ the Information Sheet, objective 8.

15. **Ask** ____ your instructor to explain the differences between the three types of fuel pumps shown in Figures 4, 5, and 6.

16. **Examine** ____ the fuel pumps displayed in your classroom.

17. **Study** ____ the Information Sheet, objective 9.

18. **Ask** ____ your instructor to explain what alterations must be made in fuel system components to enable them to handle the higher pressures used by fuel injected engines.

19. **Study** ____ the Information Sheet, objective 10.

20. **Examine** ____ the fuel filters displayed in your classroom.

21. **Study** ____ the Information Sheet, objectives 11 and 12.

22. **Study** ____ the introduction to Job Sheet 2.

23. **Ask** ____ your instructor to show you the locations where fuel pumps are installed on different vehicles.

24. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

25. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

26. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

27. **Study** ____ the introduction to Job Sheet 3.

May be photocopied for student use.

28. **Examine** _____ the various types of air filters on display in your classroom.

29. **Ask** _____ your instructor to show you the locations where air cleaners are installed on various vehicles.

30. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

31. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

32. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

33. **Study** _____ the Information Sheet, objective 15.

34. **Ask** _____ your instructor to show you samples of clean and contaminated fuels and describe the causes of such contamination.

35. **Study** _____ the introduction to Job Sheet 4.

36. **Ask** _____ your instructor to show you a fuel gauge sending unit and describe how it may become damaged or nonfunctional.

37. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

38. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

39. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

40. **Study** _____ the introduction to Job Sheet 5.

May be photocopied for student use.

Optional: Identify ____ the fuel contaminants in the sample jars your instructor has prepared.

41. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 5. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

42. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

43. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

44. **Study** ____ the introduction to Job Sheet 6.

45. **Ask** ____ your to instructor explain what problems can occur because of a malfunctioning oxygen sensor.

46. **Examine** ____ the display of oxygen sensors in your classroom.

47. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 6. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

48. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

49. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

50. **Study** ____ the introduction to Job Sheet 7.

51. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 7. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

May be photocopied for student use.

52. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

53. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

54. **Study** ____ the introduction to the Assignment Sheet.

55. **Do** ____ the Assignment Sheet.

56. **Stop** ____ and have your instructor evaluate your work. After your work has been evaluated, follow your instructor's recommendations.

57. **Take** ____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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INSTRUCTOR'S RESOURCE PACKAGE · Engine Performance Specialist
TRANSPARENCY MASTER 1 - **CIMC** · 8 · 1

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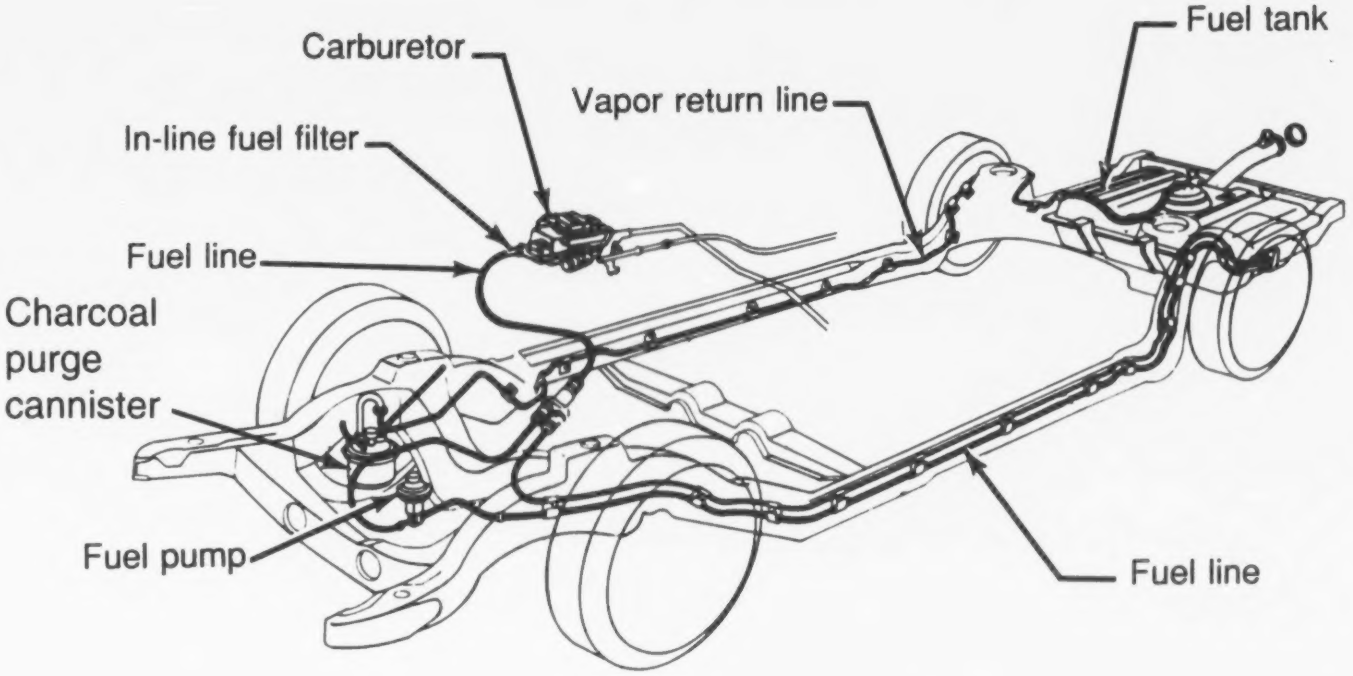
Carbureted Fuel Delivery System


Carburetor
Fuel tank
Vapor return line
In-line fuel filter
Fuel line
Charcoal purge cannister
Fuel pump
Fuel line

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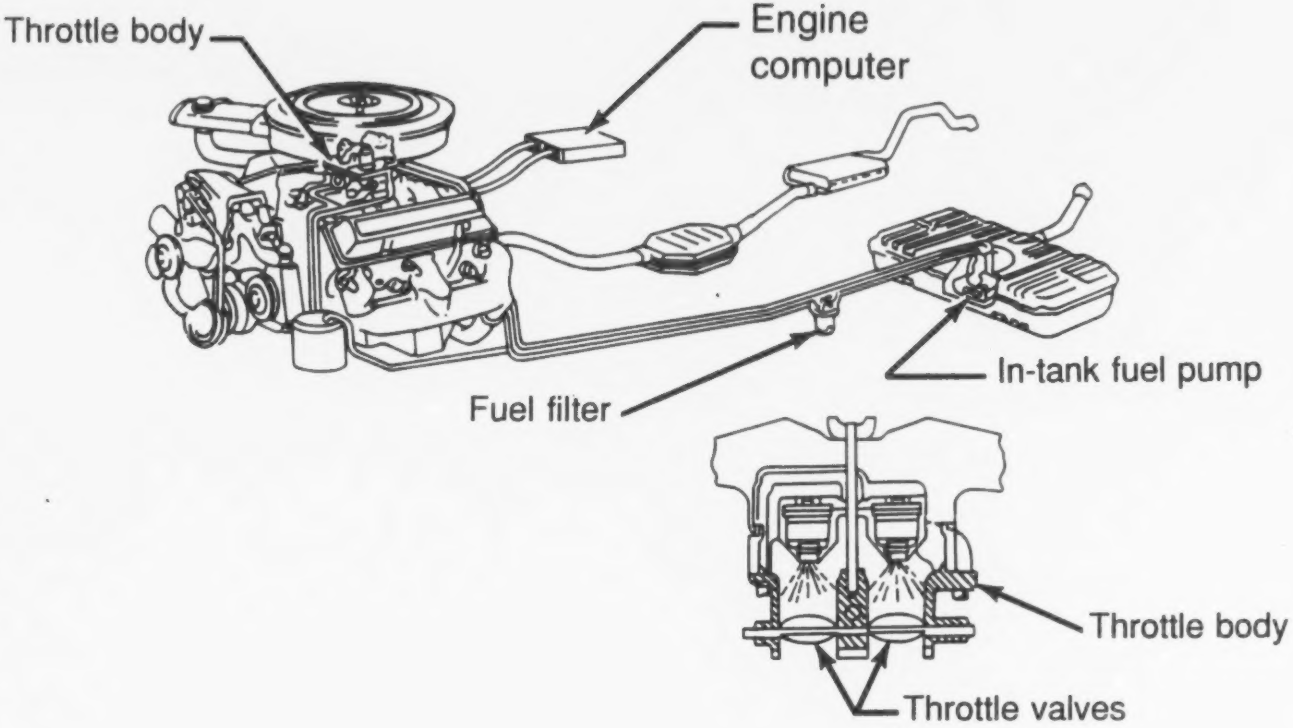
Throttle Body Fuel Injection System


Throttle body
Engine computer
In-tank fuel pump
Fuel filter
Throttle body
Throttle valves

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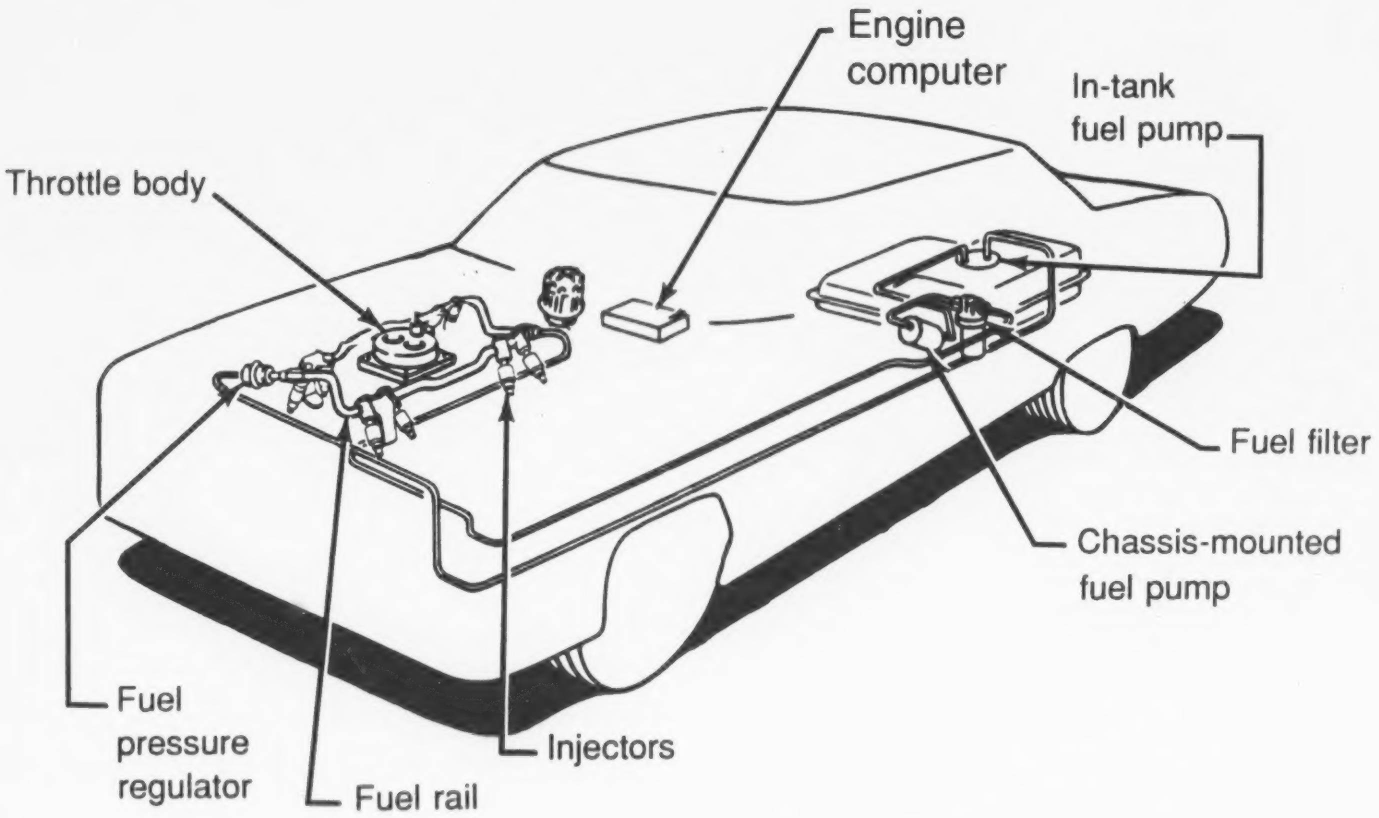
TRANSPARENCY MASTER 2 · **CIMC** · 8 · 1

TM 2

Port Fuel Injection System


Engine computer
In-tank fuel pump
Throttle body
Fuel filter
Chassis-mounted fuel pump
Fuel pressure regulator
Fuel rail
Injectors

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TRANSPARENCY MASTER 3 - **CIMC** · 8 · 1

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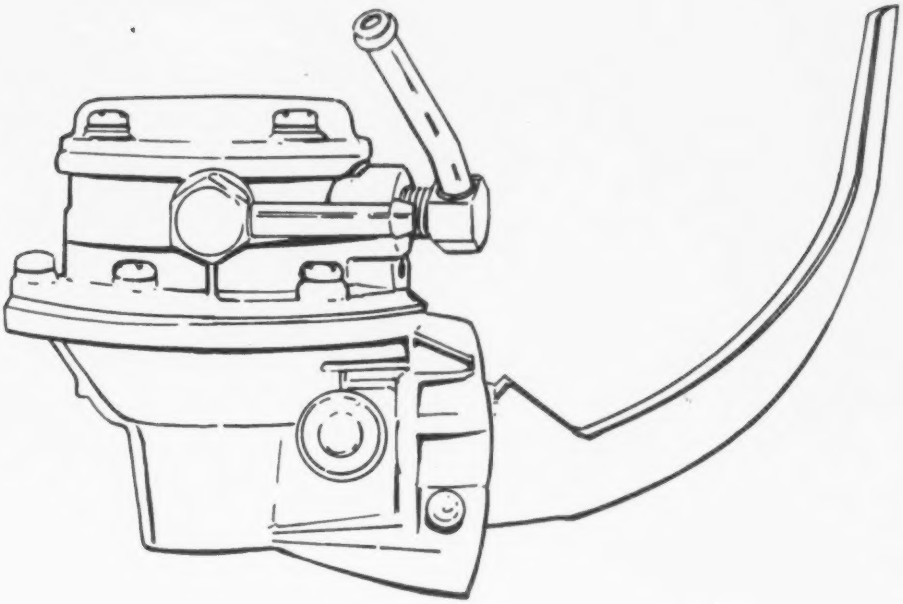
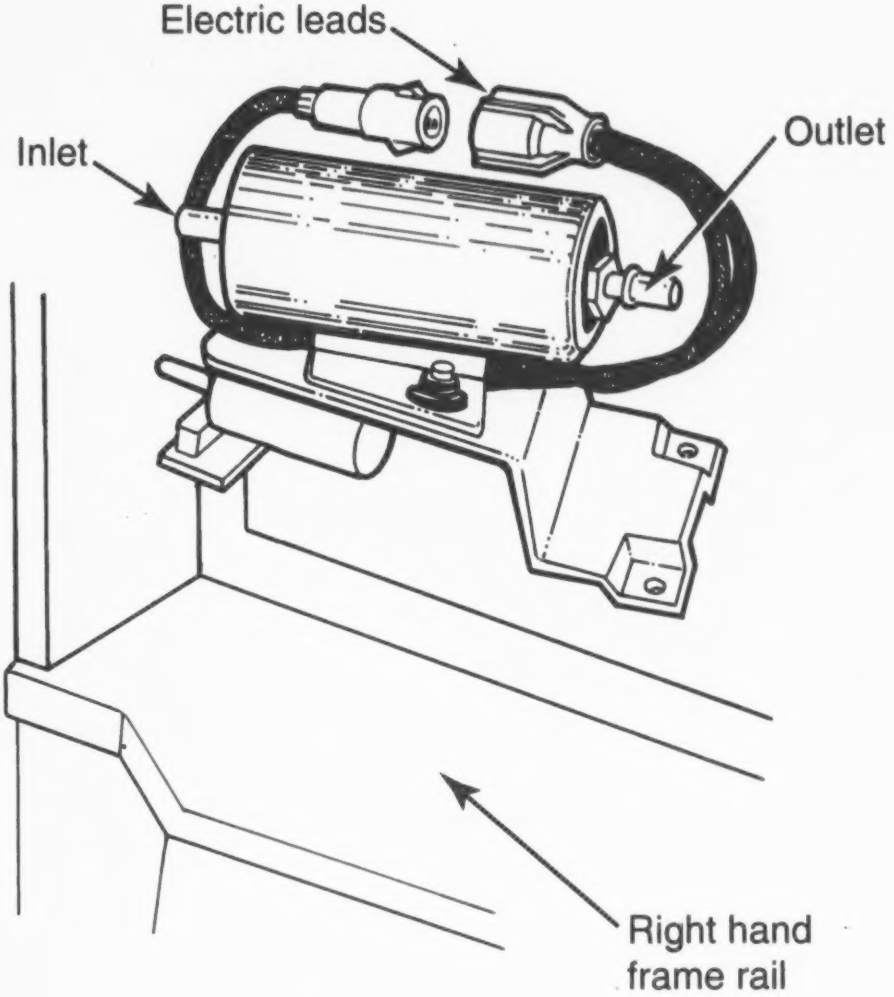
Mechanical Fuel Pump



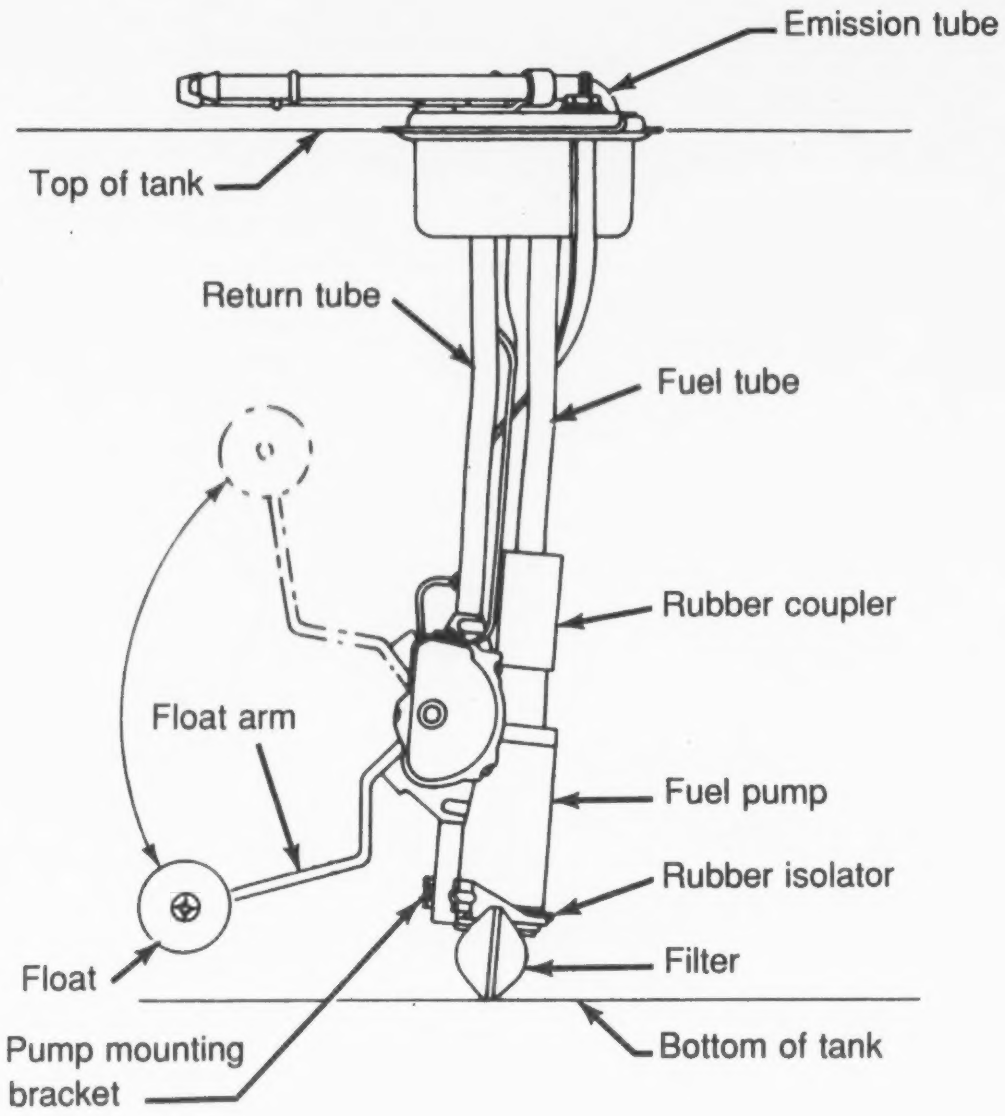
May be photocopied for student use.

External Electric Fuel Pump


Electric leads
Inlet
Outlet
Right hand frame rail

May be photocopied for student use.

Tank-mounted Electric Fuel Pump


Emission tube
Top of tank
Return tube
Fuel tube
Rubber coupler
Float arm
Fuel pump
Rubber isolator
Filter
Float
Pump mounting bracket
Bottom of tank

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WRITTEN TEST

SERVICING FUEL DELIVERY SYSTEMS

8

Name ____________________ Date ________ Score ____

OBJECTIVE 1

List the two main classifications of fuel delivery systems. Write the classifications in the blanks provided.

1. ____

2. ____

OBJECTIVE 2

Compare and contrast the two main classifications of fuel delivery systems. Compare the statements on the left to the types of fuel delivery systems on the right. Place an "X" in the appropriate column if the statement to the left applies to that type of system.

	Fuel Injected	**Carbureted**
1. Uses pressure to mix air and fuel	________	________
2. Uses vacuum to mix air and fuel	________	________
3. Delivers fuel to the engine	________	________
4. Responds quickly to changing conditions	________	________
5. Produces fewer exhaust emissions	________	________
6. Older technology	________	________
7. Newer technology	________	________
8. More precise metering of fuel	________	________
9. More efficient and cost effective	________	________

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OBJECTIVE 3

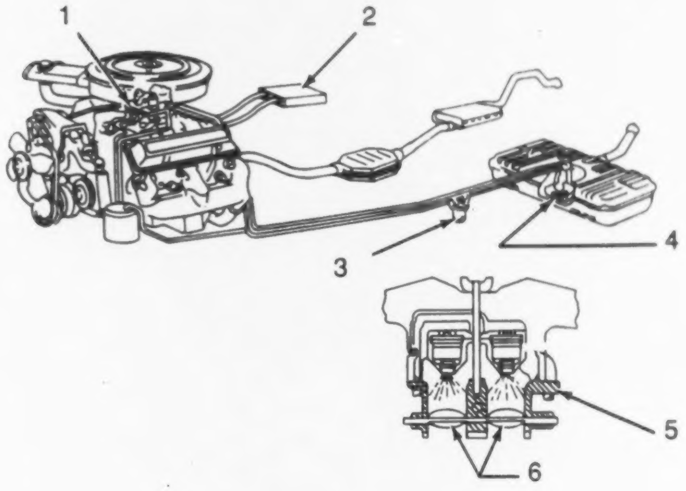
Name three types of fuel delivery systems shown in illustrations. Look at the illustrations in objective 5, and write the name of the fuel delivery systems shown in the blanks marked "A."

OBJECTIVE 4

Describe the operation of the three types of fuel delivery systems. Look at the illustrations in objective 5, and write a description of the operation of each type of fuel delivery system on the lines marked "B."

OBJECTIVE 5

Label fuel delivery system parts indicated on illustrations. Look at the following illustrations, and write the names of the indicated parts of the fuel delivery system on the numbered lines under "C."



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I. A. Type of fuel delivery system: ____________________

B. Description of its operation: ____________________

____

____

C. Label the parts indicated:

1. ____________________

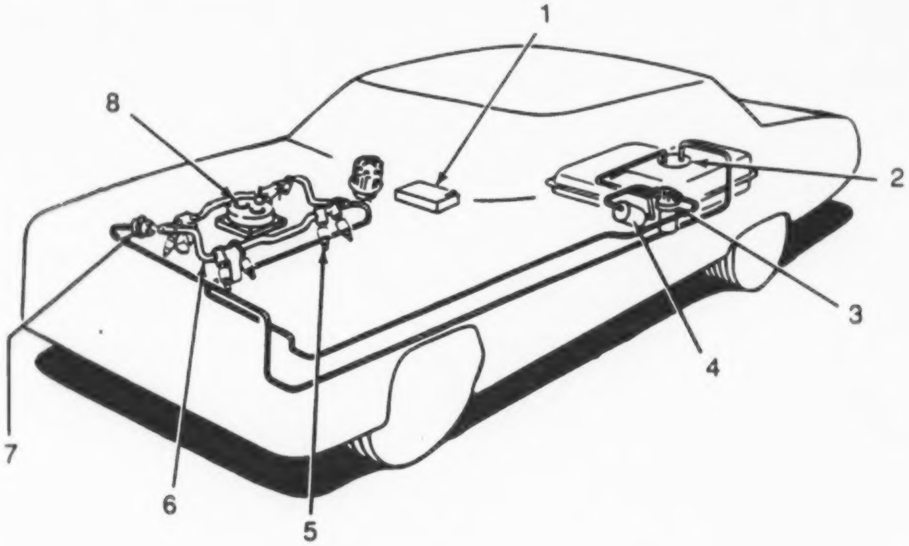
2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________



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II. A. Type of fuel delivery system: ____________________

B. Description of its operation: ____________________

____

____

C. Label the parts indicated:

1. ____________________

2. ____________________

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3. ______________________________

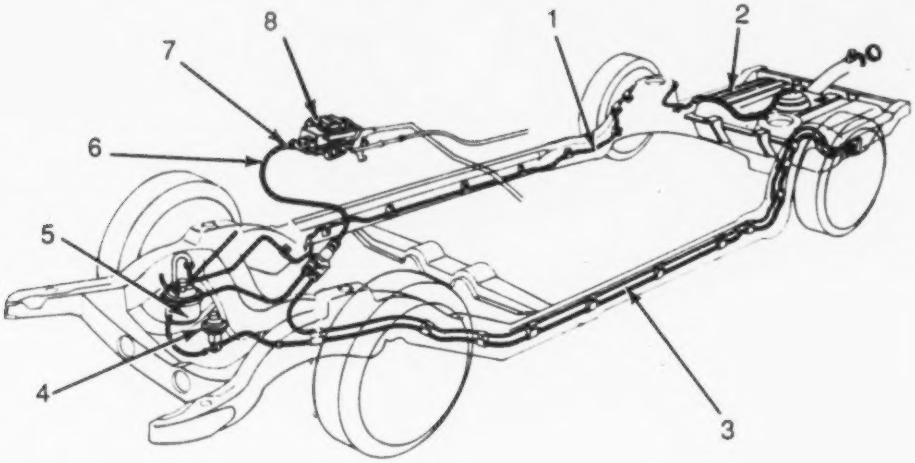
4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________



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III. A. Type of fuel delivery system: ______________________________

B. Description of its operation: ______________________________

____

____

C. Label the parts indicated:

1. ______________________________

2. ______________________________

May be photocopied for student use.

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

OBJECTIVE 6

Match the names of fuel delivery system parts to descriptions of their functions. Write the letter of the correct answer in the blank.

A. carburetor
B. charcoal canister
C. engine computer
D. fuel filter
E. fuel line
F. fuel pressure regulator
G. fuel pump
H. fuel rail
I. fuel tank
J. injector
K. throttle body
L. throttle valve
M. vapor return line

_____ 1. Holds the fuel supply for the vehicle

_____ 2. Returns gasoline vapors to the fuel tank to prevent them from venting into the atmosphere

_____ 3. Monitors vehicle operation and regulates the fuel injectors for maximum efficiency

_____ 4. Propels the fuel from the fuel tank to the engine and provides the pressure necessary for proper system operation

_____ 5. Meters and mixes gasoline with air before it enters the intake manifold

_____ 6. Contains the vaporized fuel before it is regulated into the manifold to be mixed with air

_____ 7. Carries the fuel from the fuel tank to the engine

_____ 8. Regulates the flow of air or air-fuel mixture

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_____ 9. Removes contaminants from the fuel before they reach the engine

_____ 10. Maintains steady fuel pressure in the fuel system

_____ 11. Directs pressure-regulated fuel to the injectors in a port fuel injection system

_____ 12. Sprays vaporized fuel into the intake manifold or intake port

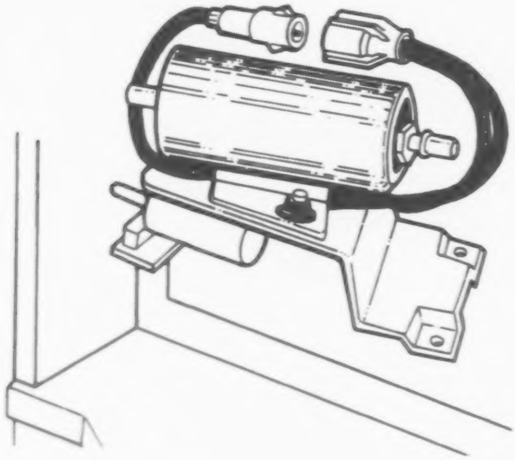
_____ 13. Stores fuel vapors from the fuel tank and the carburetor float bowl and/or intake manifold

OBJECTIVE 7

Evaluated on Job Sheet 1.

OBJECTIVE 8

Name three types of fuel pumps shown in illustrations. Write the name of the fuel pump shown on the line below the illustration.



1. ______________________________

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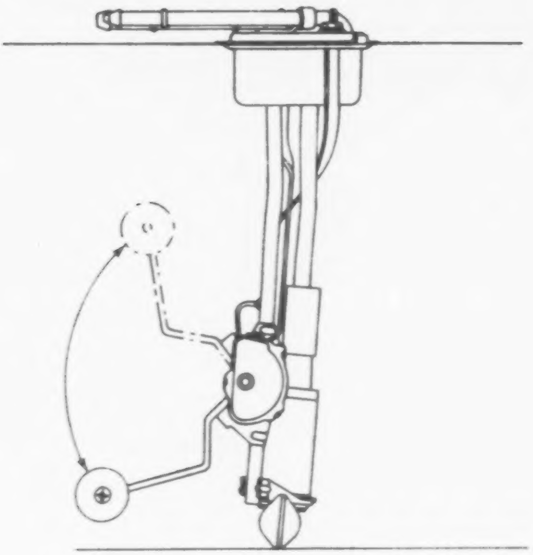

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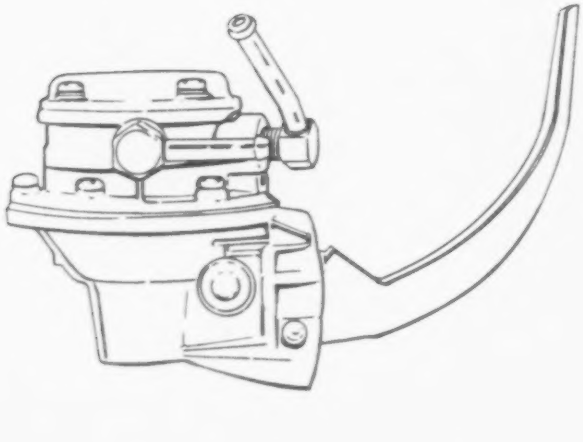
2. ____



3. ____

May be photocopied for student use.

OBJECTIVE 9

State the amount of fuel pressure present during the operation of different types of fuel systems. Write the answers on the lines provided.

1. Throttle body fuel injection ________psi

2. Port fuel injection ________psi

3. Carbureted ________psi

OBJECTIVE 10

Name types of fuel filters from examples shown in your classroom. Your instructor will display examples of four types of fuel filters, each of which will be numbered. Write the name of each type of fuel filter in the blank by the appropriate number.

1. ____

2. ____

3. ____

4. ____

OBJECTIVE 11

Compare and contrast fuel filters used in carbureted type fuel delivery systems and fuel filters used in injector type fuel delivery systems. Place a "C" in front of characteristics which apply to fuel filters for *carbureted* systems and an "F" in front of characteristics which apply to fuel filters for *fuel injected* systems. Some characteristics may apply to fuel filters for both carbureted and fuel injected fuel delivery systems.

Filter Characteristics

______________ 1. Requires occasional inspection/replacement

______________ 2. Requires more frequent inspection/replacement

______________ 3. Filters out fuel contaminants

______________ 4. Eliminates only largest particles

______________ 5. Eliminates even smallest particles

______________ 6. Operates at lower pressures

______________ 7. Operates at higher pressures

__________ 8. Less rugged design for lower pressure

__________ 9. More rugged design for higher pressure

OBJECTIVE 12

Match the names of types of fuel system diagnostic tests to statements describing the tests' purposes. Write the letter of the fuel system diagnostic test described in the blank beside number.

A. Pressure test
B. Vacuum test
C. Volume test

____ 1. Checks the ability of a pump to pull fuel from the fuel tank through the lines and filters

____ 2. Tests the amount of fuel pressure exerted when the fuel exits the fuel pump

____ 3. Determines the amount of fuel a pump can deliver over a specific amount of time

OBJECTIVE 13

Evaluated on Job Sheet 2.

OBJECTIVE 14

Evaluated on Job Sheet 3.

OBJECTIVE 15

List common fuel contaminants. Write the names of the four most common fuel contaminants on the lines below.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

OBJECTIVE 16

Evaluated on Job Sheet 4.

OBJECTIVE 17

Evaluated on Job Sheet 5.

OBJECTIVE 18

Evaluated on Job Sheet 6.

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OBJECTIVE 19 **Evaluated on Job Sheet 7.**

OBJECTIVE 20 **Evaluated on the Assignment Sheet.**

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Carbureted Fuel Delivery System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine hesitates on acceleration.	Defective carburetor	Check carburetor.
	Dirty fuel filter	Check and replace fuel filter.
	Carburetor loose on manifold	Tighten carburetor.
Engine runs uneven, "surges."	Fuel restriction	Check fuel line for restrictions. Check fuel filter.
	Fuel contamination	Drain fuel tank. Clean fuel lines and carburetor.
	Vacuum leaks	Check vacuum hoses and connectors.
Engine cranks but will not start.	No fuel in carburetor	Disconnect fuel line at carburetor. Crank engine. If no fuel appears, check the fuel line for obstructions. If the fuel line is open, check the fuel filter for obstruction. If the fuel filter is clean, check fuel pump.
	Flooded carburetor	Remove the air filter. Check for strong gasoline odor. If present, follow the vehicle service manual to check carburetor.
	Fuel pump pressure too high	Check fuel pump pressure.
Engine backfires.	Dirty air filter	Replace air filter.
	Dirty carburetor	Clean carburetor.
Power loss at high speed	Dirty fuel filter	Check fuel filter.
	Carburetor jets dirty	Clean carburetor.

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Carbureted Fuel Delivery System Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Sluggish operation, slow to accelerate	Dirty air filter	Inspect and replace as needed.
	Dirty fuel filter	Inspect and replace as needed.
	Defective fuel pump	Inspect and replace as needed.
Fuel in the oil	Defective fuel pump	Inspect and replace.
	Defective carburetor	Inspect and repair.

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Fuel Injected Delivery System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Stalling, surging, hesitation	Low fuel pressure	Check fuel filter and pump.
	Restriction in air intake	Check air filter. Replace if dirty.
	Defective oxygen sensor.	Replace oxygen sensor.
Hard start, rough idle	Defective fuel pump or fuel pump relay	Check fuel pump.
	Wrong PCV valve	Check and replace PCV valve.
	Leaking manifold gasket	Check manifold gasket.
	Defective injectors	Check injectors for leakage and proper spray pattern.
Low power	Dirty fuel filter	Check and replace fuel filter.
	Defective fuel pump	Test and replace fuel pump.
	Dirty pick-up strainer in fuel tank	Check and replace strainer.
	Defective or dirty injectors	Check injector spray pattern. Clean or replace as necessary.

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LAP
SHEET

SERVICING FUEL INJECTION SYSTEMS

9

Name ____

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

2. **Read** ____ the introduction, unit objective, and specific objectives.

3. **Do** ____ the focus assignments.

4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.

5. **Study** ____ the Information Sheet, objective 1.

6. **Ask** ____ your instructor to explain the operation of the two types of fuel injection systems shown in Figures 1 and 2.

7. **Study** ____ the Information Sheet, objectives 2-6.

8. **Ask** ____ your instructor to use Figure 3 to explain how a fuel injector works.

9. **Examine** ____ actual fuel injectors.

10. **Study** ____ the Information Sheet, objectives 7-15.

Optional Examine ____ a fuel pressure regulator.

11. **Study** ____ the Information Sheet, objectives 16-17.

12. **Study** ____ the introduction to Job Sheet 1.

13. **Ask** ____ your instructor to review the operation of a scan tool and/or an engine computer analyzer.

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14. **Ask** ____ your instructor to explain the operation of closed-loop and open-loop fuel control systems.

15. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

16. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

17. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

18. **Study** ____ the introduction to Job Sheet 2.

19. **Look** ____ at the components of an idle speed control system on an actual vehicle.

20. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

21. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

22. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

23. **Study** ____ the introduction to Job Sheet 3.

24. **Ask** ____ your instructor to explain why vacuum leaks are a common and critical source of problems with the fuel injection system.

25. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

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26. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

27. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

28. **Study** _____ the introduction to Job Sheet 4.

29. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

30. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

31. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

32. **Study** _____ the introduction to Job Sheet 5.

33. **Review** _____ the ohmmeter function of a digital multimeter.

34. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 5. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

35. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

36. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

37. **Study** _____ the introduction to Job Sheet 6.

38. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 6. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

39. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

40. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

41. **Study** _____ the introduction to Job Sheet 7.

42. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 7. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

43. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

44. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

45. **Study** _____ the introduction to Job Sheet 8.

46. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 8. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

47. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

48. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

49. **Study** _____ the introduction to Job Sheet 9.

May be photocopied for student use.

50. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 9. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

51. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation..

52. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

53. **Study** _____ the Information Sheet, objectives 27 and 28.

54. **Study** _____ the introduction to Job Sheet 10.

55. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 10. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

56. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

57. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

58. **Study** _____ the introduction to Job Sheet 11.

59. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 11. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

60. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation..

61. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

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62. **Do** ____ the Assignment Sheet, objective 31.

63. **Stop** ____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

64. **Take** ____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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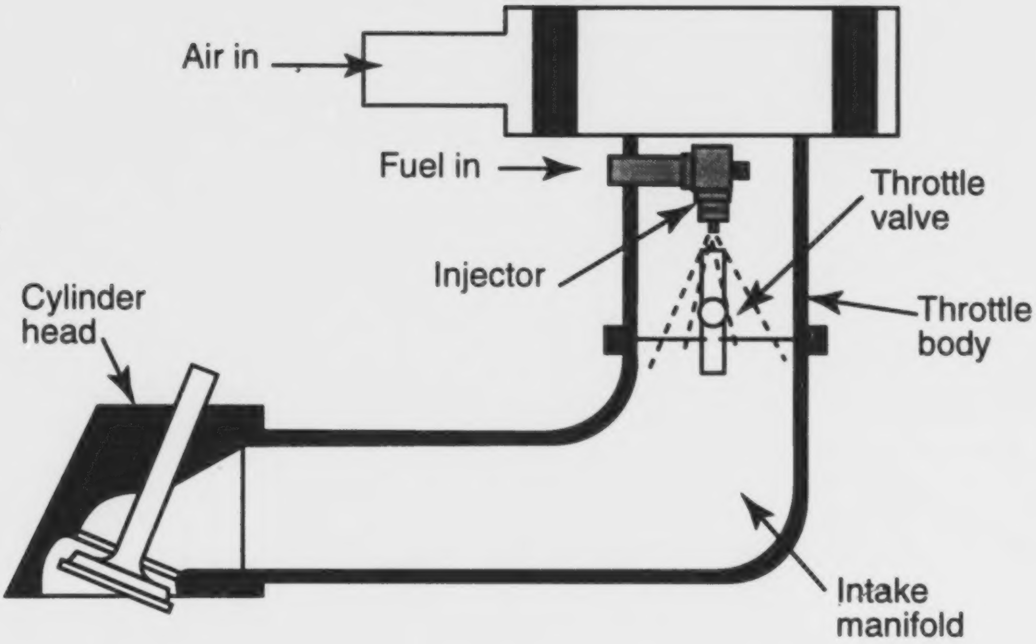
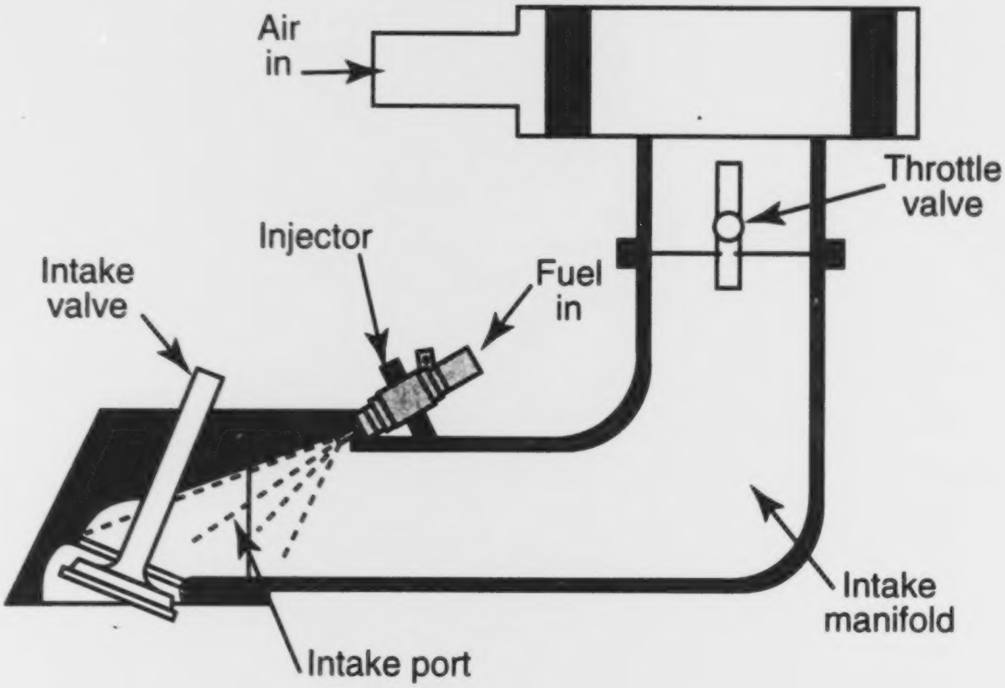
Throttle Body Fuel Injection System


Air in
Fuel in
Throttle valve
Injector
Cylinder head
Throttle body
Intake manifold

479

May be photocopied for student use.

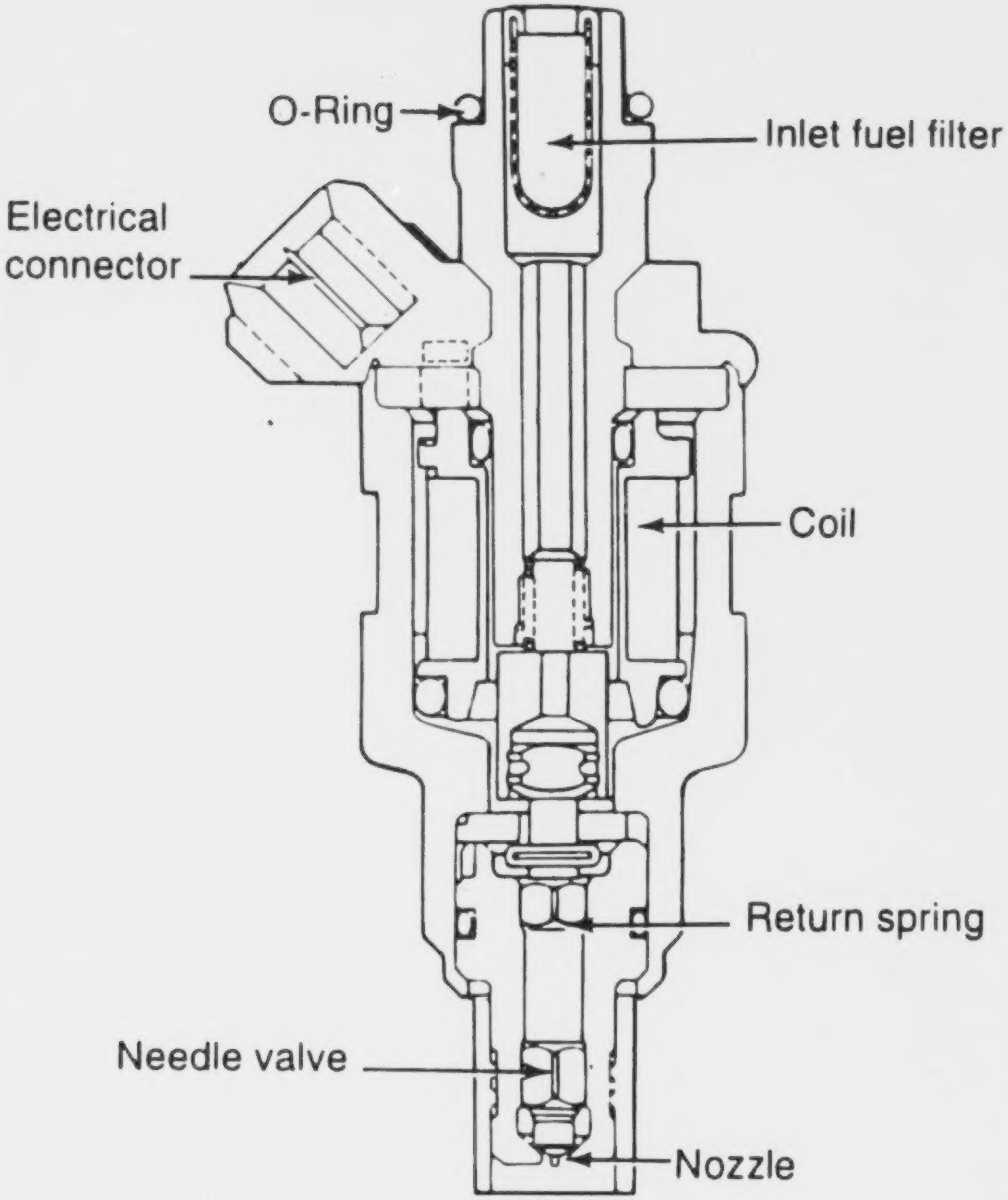
Port Fuel Injection System


Air in
Throttle valve
Injector
Intake valve
Fuel in
Intake manifold
Intake port

May be photocopied for student use.

480

Parts of a Fuel Injector


O-Ring
Inlet fuel filter
Electrical connector
Coil
Return spring
Needle valve
Nozzle

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May be photocopied for student use.

WRITTEN TEST

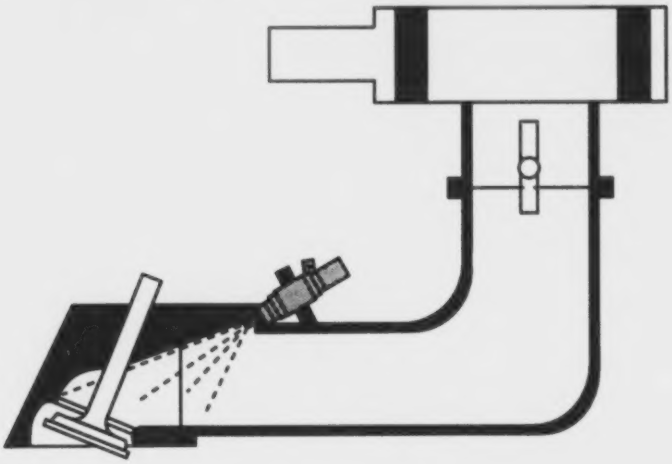
SERVICING FUEL INJECTION SYSTEMS

9

Name ______________________ Date __________ Score ____

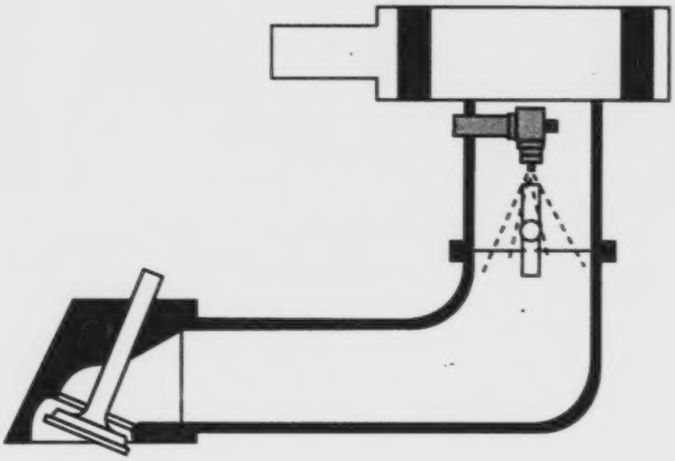
OBJECTIVE 1

Name the two types of fuel injection systems shown in illustrations. Write the name of the type of fuel injection system on the line under the illustration.



1. ____

May be photocopied for student use



2. ____

OBJECTIVE 2

State the method of fuel induction for each type of fuel injection system. Write the method of fuel induction on the lines next to the type of fuel injection system.

1. Port fuel injection: ____
2. Throttle body fuel injection: ____

OBJECTIVE 3

State the number and placement of injectors in each type of fuel injection system. Write the number and placement of injectors on the lines next to the type of fuel injection system.

1. Port fuel injection: ____

May be photocopied for student use.

2. Throttle body fuel injection: ______________________________

____

____

OBJECTIVE 4

Match the names of the two ways fuel injection systems are controlled with descriptions of their control. Write the letter of the answer in the blank before the description.

A. electronic fuel injection
B. mechanical fuel injection

_____ 1. Uses a throttle linkage, a mechanical pump, and a governor speed device to control the opening and closing of the fuel injectors

_____ 2. Uses sensors and the engine computer to control the opening and closing of the fuel injectors

OBJECTIVE 5

Match the names of methods of sequencing injectors with descriptions of the sequence. Write the letter of the answer in the blank before the description.

A. continuous
B. modulated
C. sequential

_____ 1. Sprays fuel into the intake port right before or as the intake valves open

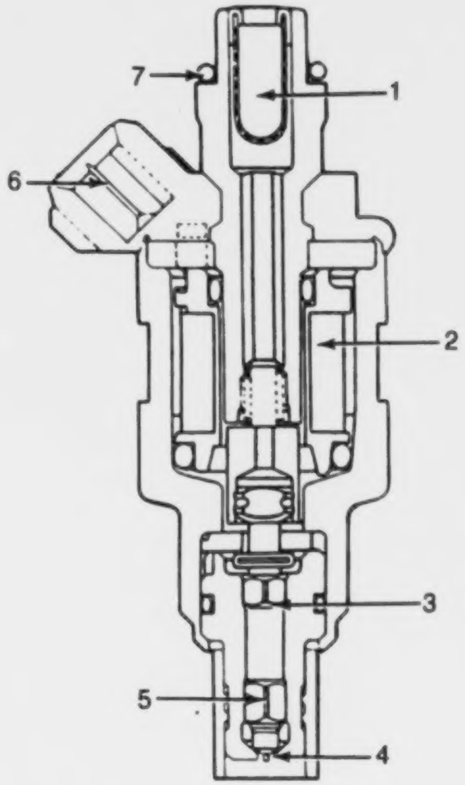
_____ 2. Opens and closes the needle of the injector independently of the engine intake valves and can spray fuel into the engine when the valves are open or when they are closed

_____ 3. Sprays fuel into the intake manifold all of the time

May be photocopied for student use.

OBJECTIVE 6

Label the parts of a fuel injector indicated on an illustration. Write the name of the part on the line beside the appropriate number.



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1. ________________________________

2. ________________________________

3. ________________________________

4. ________________________________

5. ________________________________

6. ________________________________

7. ________________________________

May be photocopied for student use.

OBJECTIVE 7

Match the names of engine monitoring and control devices which assist in fuel injection-system operation with descriptions of the conditions they monitor or control. Write the letter of the answer in the blank before the description.

A. airflow sensor
B. fuel pressure regulator
C. manifold absolute pressure (MAP) sensor
D. thermo-time switch
E. throttle position sensor (TPS)

_____ 1. Senses movement of the throttle valve so the air-fuel mixture can be adjusted for engine speed, acceleration, and deceleration

_____ 2. Senses the temperature of the engine coolant and allows or inhibits the firing of the cold start injector

_____ 3. Measures the volume of air flowing into the intake manifold so the correct air-fuel mixture can be maintained

_____ 4. Monitors the vacuum in the intake manifold so the air-fuel mixture can be enriched or leaned with changes in engine load

_____ 5. Regulates the amount of pressure entering the injector

OBJECTIVE 8

Match the names of the operating conditions of a fuel injector to descriptions of the injector's operation during each condition. Write the letter of the answer in the blank before the description. Each operating condition may be used more than once.

A. The pulse width is increased
B. A minimum pulse width is maintained for the load, speed, temperature, and other operating variables
C. The pulse width is decreased

_____ 1. Acceleration

_____ 2. Cruise

_____ 3. Deceleration

_____ 4. Idle

_____ 5. Start

May be photocopied for student use.

OBJECTIVE 9

State the function of an idle speed control system. Write the function on the lines below.

____

____

____

OBJECTIVE 10

Describe the operation of an idle speed control system. Write the description on the lines below.

____

____

____

____

____

____

____

____

____

OBJECTIVE 11

State the function of a cold start enrichment system. Write the function on the lines below.

____

____

____

____

____

OBJECTIVE 12

Arrange the steps of cold start enrichment system operation in order. Write a "1" in the blank in front of the first step, a "2" in the blank in front of the second step, and so on.

May be photocopied for student use.

____ The thermo-time switch closes, allowing the electricity to start the cold start injector.

____ The starter solenoid begins a flow of electricity to the thermo-time switch.

____ The thermo-time switch detects a cold engine.

____ The thermo-time switch shuts down the cold start injector after 10-12 seconds when the engine warms up or the preset time is past.

____ The cold start injector sprays fuel into the intake manifold and the other injectors spray fuel into the intake ports to enrich the air-fuel mixture during cranking.

____ The driver cranks the engine.

OBJECTIVE 13

State the function of an acceleration enrichment system. Write the statement of the function on the blank lines below.

____

____

____

____

____

OBJECTIVE 14

Describe the operation of an acceleration enrichment system. Write the description on the lines below.

____

____

____

____

____

____

____

____

May be photocopied for student use.

OBJECTIVE 15

State the function of a fuel pressure regulation system. Write the statement of the function on the blank lines below.

OBJECTIVE 16

Describe the operation of a fuel pressure regulation system. Write the description on the lines below.

OBJECTIVE 17

Describe the operation of a deceleration control system. Write the description on the lines below.

May be photocopied for student use.

OBJECTIVE 18	**Evaluated on Job Sheet 1.**
OBJECTIVE 19	**Evaluated on Job Sheet 2.**
OBJECTIVE 20	**Evaluated on Job Sheet 3.**
OBJECTIVE 21	**Evaluated on Job Sheet 4.**
OBJECTIVE 22	**Evaluated on Job Sheet 5.**
OBJECTIVE 23	**Evaluated on Job Sheet 6.**
OBJECTIVE 24	**Evaluated on Job Sheet 7.**
OBJECTIVE 25	**Evaluated on Job Sheet 8.**
OBJECTIVE 26	**Evaluated on Job Sheet 9.**

OBJECTIVE 27

Name the two fuel injector tests which test for clogged fuel injectors. Write the names of the two tests in the blanks marked "A" below.

1. A. Fuel injector test: ______________________________

   B. Description of the test procedure: __________________

   ____

   ____

   ____

   ____

2. A. Fuel injector test: ______________________________

May be photocopied for student use.

B. Description of the test procedure: ____________________

____

____

____

____

OBJECTIVE 28 **Describe the test procedures for these two fuel injector tests.** Write the description of the test procedure for the test named in "A" on the lines underneath it marked "B" above.

OBJECTIVE 29 **Evaluated on Job Sheet 10.**

OBJECTIVE 30 **Evaluated on Job Sheet 11.**

OBJECTIVE 31 **Evaluated on the Assignment Sheet**

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HANDOUT 1

SERVICING FUEL INJECTION SYSTEMS

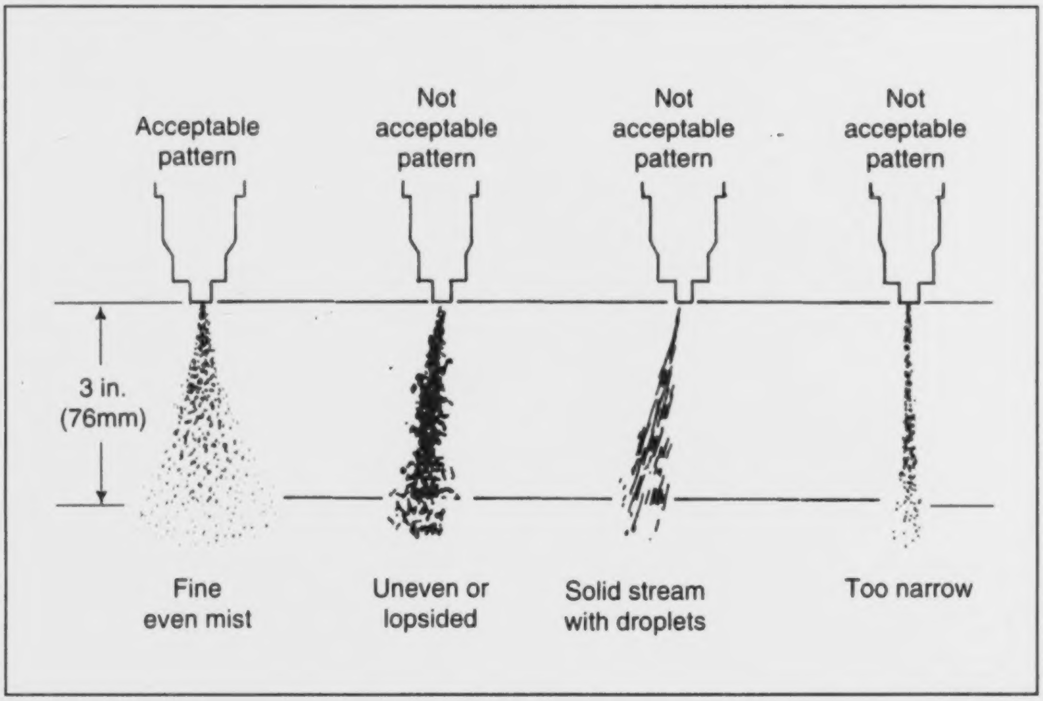
9

Comparison of Throttle Body and Port Fuel Injection Systems

	Port	Throttle Body
Electronic Fuel Injection	X	X
Mechanical Fuel Injection	X	
Direct	X	
Indirect		X
Single-point		X
Multi-point	X	
Modulated	X	X
Sequential	X	
Continuous		X

May be photocopied for student use.

Acceptable and Unacceptable Injector Spray Patterns


Acceptable pattern
Not acceptable pattern
Not acceptable pattern
Not acceptable pattern
3 in. (76mm)
Fine even mist
Uneven or lopsided
Solid stream with droplets
Too narrow

May be photocopied for student use.

Preliminary Checklist for Fuel Injection Diagnosis

Before beginning to look for problems with the fuel injection system, the following checks should be made to eliminate causes easier to identify and correct.

- Check the fuel system for fuel leaks.
- Check fuel system pressure.
- Check fuel lines for restrictions.
- Check the battery state of charge.
- Check all wiring and connections.
- Check coolant level.
- Check ignition system.
- Check air cleaner and preheat system.
- Check vacuum hoses for leaks and restrictions.

May be photocopied for student use.

Throttle Body Fuel Injection System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Hard start, cold or rough idle, cold	Coolant temperature sensor	Check coolant level or replace sensor.
	Fuel pressure bleed down	Check for fuel leak or defective fuel pump.
	Leaking manifold gasket or base gasket	Replace defective gasket.
	Manifold air temperature sensor	Replace defective manifold air temperature sensor.
	Wrong PCV valve	Replace PCV valve.
Stalling, hesitation, surging, hot or cold	Coolant temperature sensor	Check coolant level or replace sensor.
	Lower fuel system pressure	Check fuel filter and fuel pump; service or replace as required.
	Restricted air intake system	Check air cleaner and preheat system; service or replace as required.
	Throttle position sensor defective or not adjusted correctly	Check throttle position sensor; adjust or replace as required.
Hard start, hot	Bleeding injector	Inspect injector for dripping; service or replace as required.
	Leaking intake manifold gasket or base gasket	Replace defective gasket.
	Manifold absolute pressure sensor	Check manifold absolute pressure sensor and vacuum hose; service or replace as required.

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Throttle Body Fuel Injection System Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Rough idle, hot	Manifold absolute pressure sensor	Check manifold absolute pressure sensor and vacuum hose; service or replace as required.
	Coolant temperature sensor	Check coolant level or replace sensor.
	Throttle position sensor	Check throttle position sensor; adjust or replace as required.
Stalling	Idle speed control/ idle air control	Check idle speed control device; service or replace as required.
	Throttle position sensor	Check throttle position sensor: adjust or replace as required.
Poor power	Fuel filter	Check fuel filter; replace as required.
	Dirty injector	Check injector spray pattern; clean or replace injector as required.
	Fuel pump	Check fuel pump pressure; replace fuel pump.
	Fuel pump pickup strainer	Check strainer; replace as required.

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Port Fuel Injection System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Hard start, cold or rough idle, cold	Coolant temperature sensor	Check coolant level or replace sensor.
	Fuel pressure bleed down	Check for fuel leak or defective fuel pump.
	Cold start injector	Check cold start injector; service or replace as required.
	Leaking manifold gasket or base gasket	Replace defective gasket.
	Air charge temperature sensor/manifold air temperature sensor	Replace defective air charge temperature sensor/manifold air temperature sensor.
	Wrong PCV valve	Replace PCV valve.
	Warm-up regulator	Replace warm-up regulator.
	Injector	Check injectors for variation in spray pattern; clean or replace injectors as required.
	Mass airflow sensor	Check airflow meter, fuel pump contacts.
	Pressure regulator	Check pressure regulator for setting and bleed down.
Hesitation or surging, hot or cold	Coolant temperature sensor	Check coolant level or replace sensor.
	Low fuel system pressure	Check fuel filter and fuel pump; service or replace as required.

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Port Fuel Injection System Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Hesitation or surging, hot or cold (cont.)	Restricted air intake system	Check air cleaner and preheat system; service or replace as required.
	Throttle position sensor defective or not adjusted correctly	Check throttle position sensor; adjust or replace as required.
	Mass airflow sensor	Check airflow meter, fuel pump contacts.
	Air charge temperature sensor/manifold air temperature sensor	Replace defective air charge temperature sensor/manifold air temperature sensor.
	Air leak in air intake system	Check gaskets, hoses and ducting; service or replace as required.
	Defective oxygen sensor	Replace oxygen sensor.
	Defective computer	Replace computer.
Hard start, hot	Bleeding injector	Inspect injector for dripping; service or replace as required.
	Leaking intake manifold gasket or base gasket	Replace defective gasket.
	Manifold absolute pressure sensor	Check manifold absolute pressure sensor and vacuum hose; service or replace as required.
	Pressure regulator	Check pressure regulator for setting and bleed down; service or replace as required.
Rough idle, hot	Manifold absolute pressure sensor	Check manifold absolute pressure sensor and vacuum hose; service or replace as required.
	Coolant temperature sensor	Check coolant level or replace sensor.
	Throttle position sensor	Check throttle position sensor; adjust or replace as required.
	Injector	Check injector or variation in spray pattern; clean or replace injector as required.

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Port Fuel Injection System Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Rough idle, hot (cont.)	Oxygen sensor	Replace oxygen sensor.
	Defective computer	Replace computer.
	Idle speed control/idle air control	Check idle speed control device; service or replace as required.
Stalling	Idle speed control/idle air control	Check idle speed control device; service or replace as required.
	Throttle position sensor	Check throttle position sensor; adjust or replace as required.
	Manifold absolute pressure sensor	Check manifold absolute pressure sensor and vacuum hose; service or replace as required.
Poor power	Fuel filter	Check fuel filter; replace as required.
	Dirty injector	Check injector spray pattern; clean or replace injector as required.
	Fuel pump	Check fuel pump pressure; replace fuel pump.
	Fuel pump pickup strainer	Check strainer; replace as required.
	Pressure regulator	Check pressure regulator for setting and bleed down; service or replace as required.

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LAP
SHEET

SERVICING TURBOCHARGER SYSTEMS

10

Name ______________________________

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

2. **Read** ____ the introduction, unit objective, and specific objectives.

3. **Do** ____ the focus assignments.

4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.

5. **Study** ____ the Information Sheet, objective 1.

6. **Ask** ____ your instructor to explain the function of a turbocharger/supercharger.

7. **Study** ____ the Information Sheet, objective 2.

8. **Examine** ____ the parts of an actual turbocharger.

9. **Study** ____ the Information Sheet, objective 3.

10. **Ask** ____ your instructor to describe the function of each turbocharger part shown in Figure 1.

Optional: Write ____ a short description of the way a turbocharger operates. Include each part and its function.

11. **Study** ____ the Information Sheet, objective 4.

12. **Ask** ____ your instructor to explain the reasons why lubrication is important for a turbocharger.

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13. **Examine** ____ parts of a turbocharger that have been damaged from a lack of proper lubrication.

14. **Study** ____ the introduction to Job Sheet 1.

15. **Ask** ____ your instructor to explain the things you should look and listen for when testing the operation of a turbocharger.

16. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

17. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

18. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

19. **Study** ____ the introduction to Job Sheet 2.

20. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

21. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

22. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

23. **Study** ____ the introduction to Assignment Sheet 1.

24. **Do** ____ Assignment Sheet 1.

25. **Stop** ____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

26. **Study** ____ the Information Sheet, objective 8.

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27. **Examine** _____ the parts of a supercharger.

28. **Study** _____ the Information Sheet, objective 9.

29. **Ask** _____ your instructor to describe the function of each part of a supercharger shown in Figure 2.

Optional: Write _____ a short description of how a supercharger operates. Include each part and its function.

30. **Study** _____ the Information Sheet, objective 10.

31. **Ask** _____ your instructor to explain the similarities and differences between a turbocharger and a supercharger.

32. **Study** _____ the introduction to Job Sheet 3.

33. **Ask** _____ your instructor to explain what you should look and listen for when you are testing the operation of a supercharger.

34. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

35. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

36. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

37. **Study** _____ the introduction to Job Sheet 4.

38. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

39. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

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40. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

41. **Study** ____ the introduction to Assignment Sheet 2.

42. **Do** ____ Assignment Sheet 2.

43. **Stop** ____ and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.

44. **Take** ____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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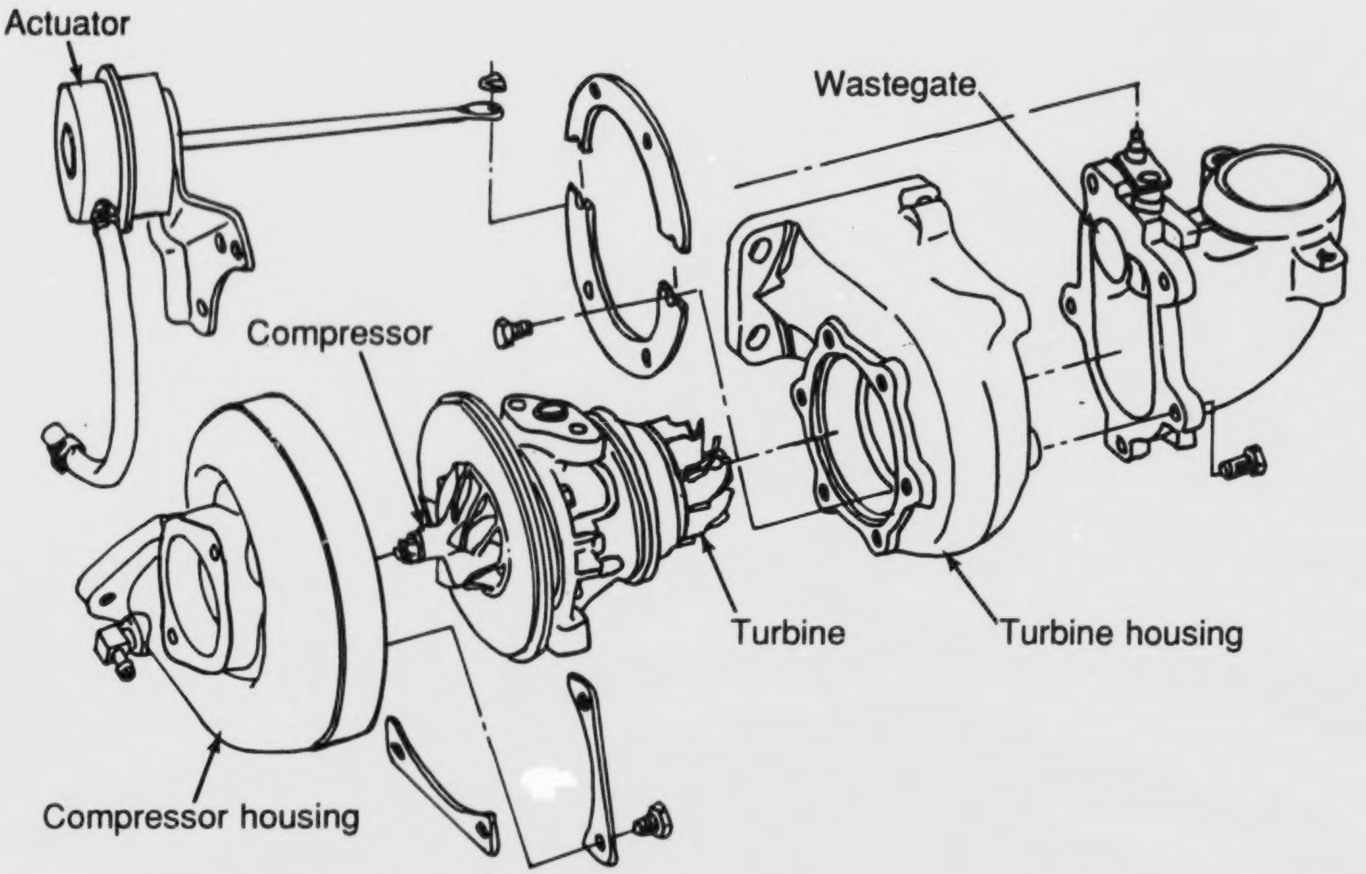
Parts of a Turbocharger


Actuator
Wastegate
Compressor
Turbine
Turbine housing
Compressor housing

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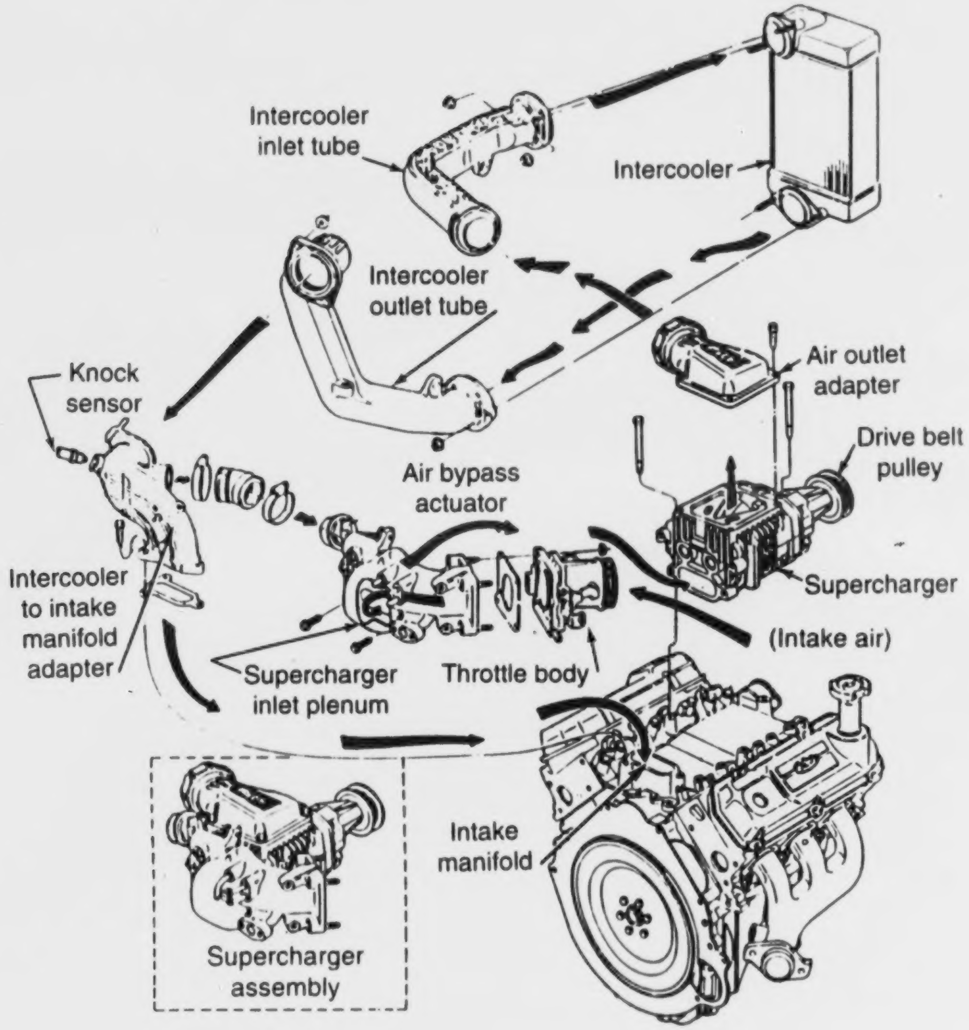
Parts of a Supercharger


Intercooler inlet tube
Intercooler
Intercooler outlet tube
Knock sensor
Air outlet adapter
Drive belt pulley
Air bypass actuator
Intercooler to intake manifold adapter
Supercharger
(Intake air)
Supercharger inlet plenum
Throttle body
Intake manifold
Supercharger assembly

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WRITTEN TEST

SERVICING TURBOCHARGER SYSTEMS

10

Name ______________________________ Date _________ Score ___

OBJECTIVE 1

State the function of a turbocharger/supercharger. Write your answer in the space provided.

____

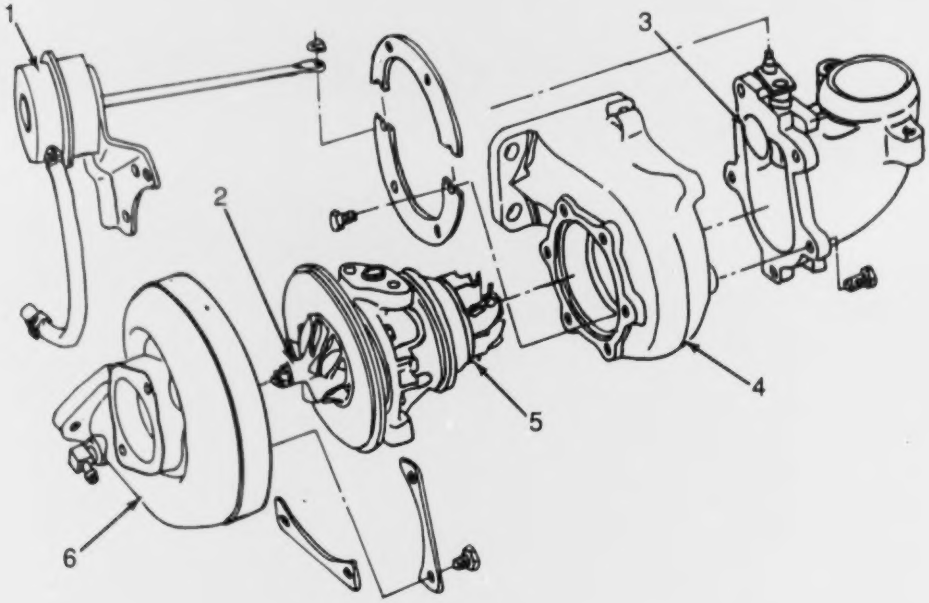
____

____

____

OBJECTIVE 2

Label the parts of a turbocharger indicated on an illustration. Put the name of the part indicated in the corresponding blank.



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1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

OBJECTIVE 3

Match the names of the parts of a turbocharger to descriptions of their functions. Write the correct letter in each blank.

A. actuator
B. compressor
C. compressor housing
D. turbine
E. turbine housing
F. wastegate

_____ 1. Contains and protects the compressor

_____ 2. Opens and closes the wastegate in response to intake manifold pressure

_____ 3. Contains and protects the turbine

_____ 4. Forces air into the intake manifold

_____ 5. A fan-bladed wheel, turned by exhaust gases, which powers the compressor

_____ 6. Channels excess exhaust gases away from the turbine

OBJECTIVE 4

List the reasons why lubrication is important for a turbocharger. Write your answers in the spaces provided.

1. ______________________________
2. ______________________________
3. ______________________________

OBJECTIVE 5

Evaluated on Job Sheet 1.

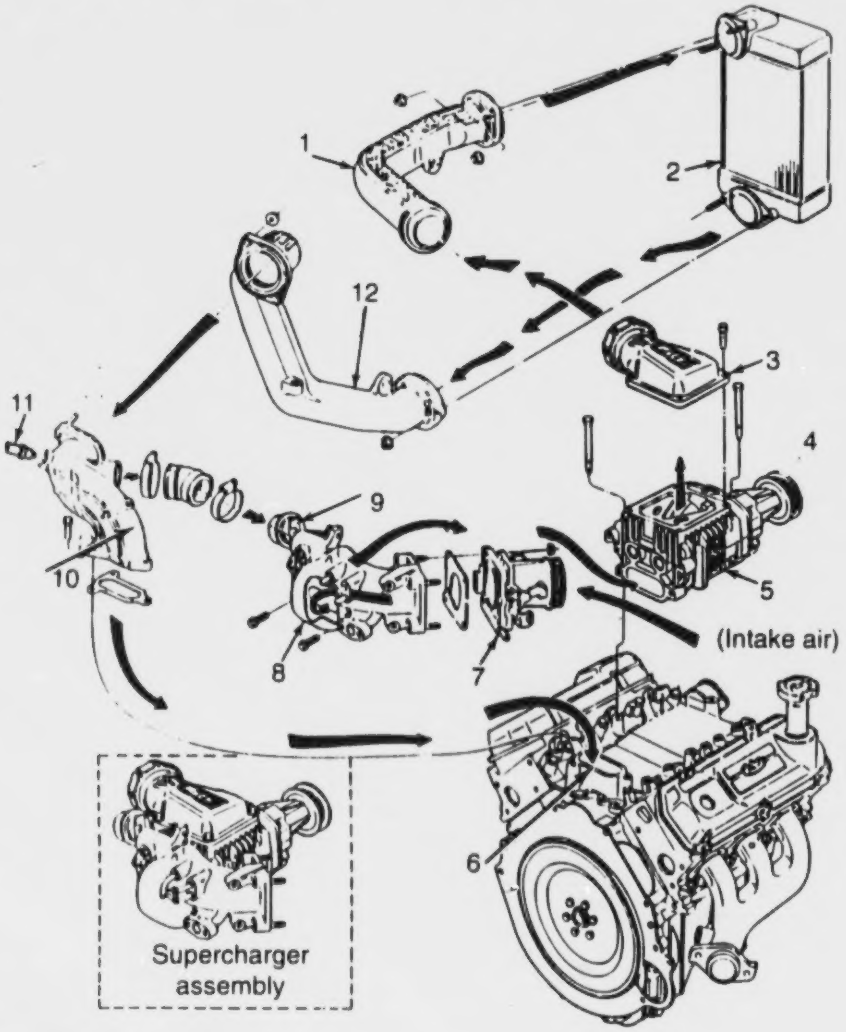
OBJECTIVE 6

Evaluated on Job Sheet 2.

May be photocopied for student use.

OBJECTIVE 7 **Evaluated on Assignment Sheet 1.**

OBJECTIVE 8 **Label the parts of a supercharger indicated on an illustration.** Put the name of the part indicated in the corresponding blank.


1
2
12
3
11
4
9
10
5
(Intake air)
8
7
6
Supercharger assembly

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1. ______________________________

2. ______________________________

3. ______________________________

May be photocopied for student use.

4. ____

5. ____

6. ____

7. ____

8. ____

9. ____

10. ____

11. ____

12. ____

OBJECTIVE 9

Match the names of the parts of a supercharger to descriptions of their functions. Write the correct letter in each blank.

A. air bypass actuator
B. air outlet adapter
C. drive belt pulley
D. intake manifold
E. intercooler
F. intercooler inlet tube
G. intercooler outlet tube
H. intercooler to intake manifold adapter
I. knock sensor
J. supercharger
K. supercharger inlet plenum
L. throttle body

_____ 1. Mixes and measures the amount of air that goes into the supercharger

_____ 2. Tubes through which the air-fuel mixture flows from the throttle valve to the intake ports in the cylinder head

_____ 3. Reduces the temperature of the hot compressed air coming from the supercharger

_____ 4. Signals the engine computer to retard the ignition spark if detonation begins

_____ 5. Compresses air for combustion in engine cylinders in direct relationship to engine crankshaft speed

_____ 6. Directs excess air in the intake manifold back to the supercharger inlet plenum

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____ 7. Directs the hot compressed air into the intercooler

____ 8. Directs the hot compressed air from the supercharger to the intercooler inlet tube

____ 9. Transfers energy from the engine crankshaft to operate the supercharger

____ 10. Directs cooled compressed air leaving the intercooler

____ 11. Directs cooled compressed air leaving the intercooler to the intake manifold

____ 12. Allows outside air to enter the supercharger

OBJECTIVE 10 **Compare and contrast a turbocharger and a supercharger.** Write your answers in the spaces provided.

	Turbocharger	**Supercharger**
Function		
Performance		
Operation		
Lubrication System		
Normal Unit Noise		

OBJECTIVE 11 **Evaluated on Job Sheet 3.**

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OBJECTIVE 12	**Evaluated on Job Sheet 4.**
OBJECTIVE 13	**Evaluated on Assignment Sheet 2.**

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Turbocharger Diagnosis Chart

The most probable causes are listed first.

☑ **NOTE:** EGR = exhaust gas recirculation system, EFE = early fuel evaporation system, ESC = electronic spark control system

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine detonation	Malfunction in spark advance or retard system	Check ignition system.
	EGR system defect	Check EGR system.
	Throttle body or turbocharger air inlet restrictions	Remove restrictions.
	Actuator allows too much boost	Check boost pressure and adjust.
	Defect in throttle body power system	Inspect and repair throttle body.
	Internal turbocharger defect	Replace turbocharger.
Low engine power	Air inlet restriction	Remove restriction from inlet.
	Exhaust system restriction	Remove restriction.
	Malfunction in spark advance or retard system	Check ignition system.
	EFE system defect	Check EFE system operation.
	EGR system defect	Check EGR system.

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Turbocharger Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine noise	EFE system defect	Check EFE system operation.
	Loose exhaust system or leak	Check exhaust mounting and connections.
	Air system defect	Check air system.
	Restricted turbocharger oil supply	Check oil delivery system.
Engine surges	ESC malfunction	Check ESC system.
	Engine vacuum leaks	Repair vacuum leaks.
	EGR system defect	Check EGR system.
	Loose turbocharger bolts on compressor side	Check mounting bolts and tighten.
Excessive oil consumption (blue exhaust smoke)	Leak at turbocharger oil inlet	Check fittings and repair.
	Turbocharger oil drain hose leaks or restricted	Check drain hose for restrictions or loose fittings.
	Turbocharger seals leaking	Replace turbocharger.

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Supercharger Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Supercharger is noisy	Rough engine idle.	Perform engine idle diagnosis.
	Air/vacuum leaks/high pitch whistle.	Perform induction system leak tests.
	Bypass valve actuator not opening.	Check that bypass actuator is operating. Check that bypass vacuum tube is connected. Check for kinked or damaged vacuum tube. Check for stuck or restricted valve. Check for stuck bypass actuator rod. Check stop adjustments of actuator.
	Low supercharger oil level.	Check supercharger oil level. Replace the supercharger if there is no oil.
	Foreign object ingestion.	Remove supercharger outlet adapter. Visually inspect rotors for damage from foreign object ingestion. If rotors are damaged, replace supercharger. ☑ **NOTE:** Foreign material may have passed through the supercharger into the engine.
	Gear rattle.	A rattle/growl at engine idle and just off idle. This is a typical noise that does not effect durability or function. ☑ **NOTE:** Rough engine idle and bypass valve actuator not opening can cause excessive gear rattle.

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Supercharger Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
	Chirp.	A high pitch chirping noise (similar to belt chirp) at engine idle and just off idle. This is a typical noise that does not effect durability or function. ☑ **NOTE:** Rough engine idle and bypass valve actuator not opening can cause excessive chirp.
Low boost	Air/vacuum leaks.	Perform induction system leak tests.
	Plugged air cleaner/air inlet.	Inspect/replace air cleaner and check for plugged air inlet.
	Supercharger not turning.	Check drive belt tension and condition. Check for supercharger seizure/foreign object. Remove supercharger outlet adapter. Visually inspect rotors for damage/seizure. If rotors are damaged, replace supercharger. ☑ **NOTE:** Foreign material may have passed through the supercharger into the engine.
	Bypass valve actuator not closing.	Check that bypass actuator is operating. Check stop adjustments of actuator.
	Insufficient flow from supercharger.	Check for stuck actuator. Remove supercharger outlet adapter and check that rotors turn when supercharger pulley is turned.
High Boost	Plugged exhaust system.	Check for plugged exhaust. Check for melted catalytic converters. Check for plugged exhaust manifolds (core sand).

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Supercharger Diagnosis Chart (continued)

High boost (cont.)	Supercharger overspeed.	Check for plugged charge air cooler tubes (core sand). Check for correct supercharger pulley. Aftermarket pulleys turn supercharger too fast and could result in supercharger seizure.
Vehicle response too "touchy" and/or poor fuel economy	Bypass valve actuator not opening.	Check that bypass actuator is operating. Check that bypass vacuum tube is connected. Check for kinked or damaged vacuum tube. Check for stuck or restricted valve. Check for stuck bypass actuator rod. Check stop adjustments of actuator.
Oil on outside of supercharger	Supercharger sealed joints leaking.	Check supercharger oil level and top off as required. Some oil seepage may occur with mileage. Oil level should be checked and topped off every 30,000 miles. If oil loss is excessive, replace the supercharger.
	Supercharger front shaft seal.	Check supercharger oil level and top off as required. Some oil seepage may occur with mileage. Oil level should be checked and topped off every 30,000 miles. If oil loss is excessive, replace the supercharger.
	Oil leak at supercharger outlet adapter mounting joint or any charge air cooler tube joint.	This is typically engine oil that is ingested through the supercharger from the positive crankcase ventilation (PCV) system. Check and service the PCV system as required. ☑ **NOTE:** Some engine oil pullover is normal and cannot be eliminated.
	Loose supercharger oil fill plug.	Check supercharger oil level and top off as required. Tighten the supercharger oil fill plug.

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LAP SHEET

SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

11

Name ______________________________

Check the blank as you complete each step.

1. **Take**	____	the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read**	____	the introduction, unit objective, and specific objectives.
3. **Do**	____	the focus assignments.
4. **Stop**	____	and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study**	____	the Information Sheet, objectives 1 and 2.
6. **Ask**	____	your instructor to explain how a positive crankcase ventilation system operates. Look at Figure 1 for reference during the explanation.
7. **Study**	____	Information Sheet, objective 3.
8. **Ask**	____	your instructor to show you examples of positive crankcase ventilation systems on different vehicles.
9. **Study**	____	the introduction to Job Sheet 1.
10. **Ask**	____	your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.
11. **Practice**	____	the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

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12. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

13. **Study** ____ the introduction to Job Sheet 2.

14. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

15. **Practice** ____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

16. **Stop** ____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

17. **Take** ____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

May be photocopied for student use.

WRITTEN TEST

SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

11

Name ______________________________ Date _________ Score ___

OBJECTIVE 1

State the purpose of a positive crankcase ventilation system. Write your answer on the lines below.

OBJECTIVE 2

Describe the operation of a positive crankcase ventilation system. Write your description on the lines below.

May be photocopied for student use.

OBJECTIVE 3 **List the locations on a vehicle where a positive crankcase ventilation system may be installed.** List the locations in the blanks below.

1. ____
____

2. ____
____

OBJECTIVE 4 **Evaluated on Job Sheet 1.**

OBJECTIVE 5 **Evaluated on Job Sheet 2.**

May be photocopied for student use.

SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

Positive Crankcase Ventilation System Diagnosis Chart

Most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine runs rough when idling.	Vacuum hose loose, cracked, or damaged	Tighten or replace vacuum hose as necessary.
Oil leaks from valve cover.	PCV valve loose at grommet	Connect PCV valve to grommet.
	Leaking valve cover	Tighten valve cover.
	Excessive crankcase pressure	Repair engine.
Engine has high backpressure or oily air filter.	PCV valve clogged	Replace PCV valve.
No vacuum coming from end of vacuum hose when disconnected	PCV valve clogged	Replace PCV valve.
	Hose clogged or collapsed	Unclog or replace hose.
	Carbon/sludge build-up in intake manifold	Remove carbon as required.
Engine doesn't start.	Vacuum hose disconnected.	Connect vacuum hose to intake manifold.

May be photocopied for student use.

LAP
SHEET

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

12

Name ____

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read** ____ the introduction, unit objective, and specific objectives.
3. **Do** ____ the focus assignments.
4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study** ____ the Information Sheet, objective 1.
6. **Ask** ____ your instructor to explain the role vehicle emissions play in air pollution.
7. **Study** ____ the Information Sheet, objectives 2 and 3.
8. **Ask** ____ your instructor to explain how vehicle driveability can be affected by EGR operation during specific engine operating conditions.
9. **Study** ____ the Information Sheet, objective 4.
10. **Examine** ____ different types of EGR valves.
11. **Ask** ____ your instructor to tell you some of the many different names vehicle manufacturers have for EGR valves and EGR systems.
12. **Study** ____ the introduction to Job Sheet 1.
13. **Review** ____ the information in Unit 6 regarding the operation of computer analyzers and scan tools.

May be photocopied for student use.

14. **Review** ____ the Handout, Exhaust Gas Recirculation System Diagnosis Chart.

15. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

16. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

17. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

18. **Study** ____ the introduction to Job Sheet 2.

19. **Ask** ____ your instructor to show the EGR wiring and electrical/ electronic controls in several makes and models of vehicles.

20. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

21. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

22. **Stop** ____ and have your instructor evaluate your work from appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

23. **Study** ____ the introduction to Job Sheet 3.

24. **Ask** ____ your instructor to show you the location of EGR vacuum/pressure controls, filters, and hoses in several makes and models of vehicles.

25. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

May be photocopied for student use.

26. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

27. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

28. **Study** ____ the introduction to Job Sheet 4.

29. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

30. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

31. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

32. **Take** ____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

May be photocopied for student use.

WRITTEN TEST

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

12

Name ______________________________ Date _________ Score ___

OBJECTIVE 1

State the function of an exhaust gas recirculation (EGR) system. Write a statement of the function on the lines below.

____

____

____

____

OBJECTIVE 2

Describe the operation of an exhaust gas recirculation system. Write a brief description on the lines below.

____

____

____

____

____

OBJECTIVE 3

Identify whether an exhaust gas recirculation system is on or off during specified engine operating conditions. Write "on" or "off" in the blank line before the condition.

_____ 1. cold engine

_____ 2. acceleration

_____ 3. deceleration

_____ 4. cruise

_____ 5. idle

May be photocopied for student use.

OBJECTIVE 4

Match the names of types of exhaust gas recirculation systems to descriptions of their operation. Write the letter of the answer on the blank line provided beside the number of the description.

A. backpressure control EGR system
B. built-in electronic EGR system
C. simple EGR system
D. thermal vacuum EGR system
E. valve sensor EGR system

_____ 1. Regulates the flow of exhaust gas into the intake manifold based on the amount of exhaust gas backpressure in the exhaust manifold

_____ 2. Opens whenever engine conditions apply vacuum to the passage between the exhaust manifold and the intake manifold, allowing exhaust gases to flow into the intake manifold

_____ 3. Senses engine temperature and prevents exhaust gas flow until the engine temperature reaches manufacturer's specifications

_____ 4. Uses voltage signals from the engine computer through solenoids to electronically regulate vacuum pressure and exhaust gas flow

_____ 5. Sensor monitors combustion temperature and relays this information to the engine computer which opens or closes the EGR valve to maintain an effective level of exhaust flow into the intake manifold.

OBJECTIVE 5 **Evaluated on Job Sheet 1.**

OBJECTIVE 6 **Evaluated on Job Sheet 2.**

OBJECTIVE 7 **Evaluated on Job Sheet 3.**

OBJECTIVE 8 **Evaluated on Job Sheet 4.**

May be photocopied for student use.

Exhaust Gas Recirculation System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine idles rough and/or stalls	Misrouted EGR valve vacuum hoses	Check routing and reroute as required.
	Leaking EGR valve	Remove or replace.
	Loose EGR valve gasket connection	Check connection; tighten as required.
	Defective EGR valve gasket	Remove and replace.
	Defective thermo control valve and/or EGR-TVS	Remove and replace.
	Improper vacuum to EGR valve at idle	Check vacuum readings; repair and service as necessary.
Engine runs rough at light acceleration	Misrouted EGR valve vacuum hoses	Check routing and reroute as required.
	Loose valve	Tighten as required.
	Failed EGR vacuum control valve	Check vacuum readings; repair and service as necessary.
	Sticking or binding EGR valve	Remove and replace.
	Missing or wrong type EGR gasket(s) and/or spacer	Install gasket(s) and/or spacer. Tighten as necessary.
Engine stalls on deceleration	Restricted control valve or air flow	Remove restriction.

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Exhaust Gas Recirculation System Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Engine stalls on deceleration (continued)	Restricted vacuum line or valve vacuum signal tube	Remove restriction.
	Sticking or binding EGR valve	Remove and replace.
Part throttle engine detonation	Restricted control valve or air flow	Remove restriction.
	Insufficient exhaust gas recirculation flow during part throttle accelerations	Check hoses for routing and restrictions. Reroute or remove restriction as necessary.
	Defective EGR valve	Remove and replace.
Cold engine starts but stalls immediately	Misrouted EGR hoses	Check routing and reroute as required.
	Malfunctioning EGR TVS system	Repair or replace as required.

May be photocopied for student use.

LAP
SHEET

SERVICING AIR INJECTION SYSTEMS

13

Name ____

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read** ____ the introduction, unit objective, and specific objectives.
3. **Do** ____ the focus assignments.
4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study** ____ the Information Sheet, objectives 1 - 3.
6. **Ask** ____ your instructor to explain the operation of the pump type air injection system shown in Figure 1.
7. **Study** ____ the Information Sheet, objective 4.
8. **Ask** ____ your instructor to explain the function of pump type air injection system parts as you examine them.
9. **Study** ____ the Information Sheet, objective 5.
10. **Ask** ____ your instructor to explain the operation of the pulse air injection system shown in Figure 2.
11. **Study** ____ the introduction to Job Sheet 1.

Optional: Make ____ an individual reference notebook from Job Sheet assignments. Review the notebook before certification testing.

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12. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

13. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

14. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

15. **Study** ____ the introduction to Job Sheet 2.

16. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

17. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

18. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

19. **Study** ____ the introduction to Job Sheet 3.

20. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

21. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

22. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

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23. **Study** ____ the introduction to Job Sheet 4.

24. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 4. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

25. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

26. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

27. **Study** ____ the introduction to Job Sheet 5.

28. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 5. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

29. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

30. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

31. **Study** ____ the introduction to Job Sheet 6.

32. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 6. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

33. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

34. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

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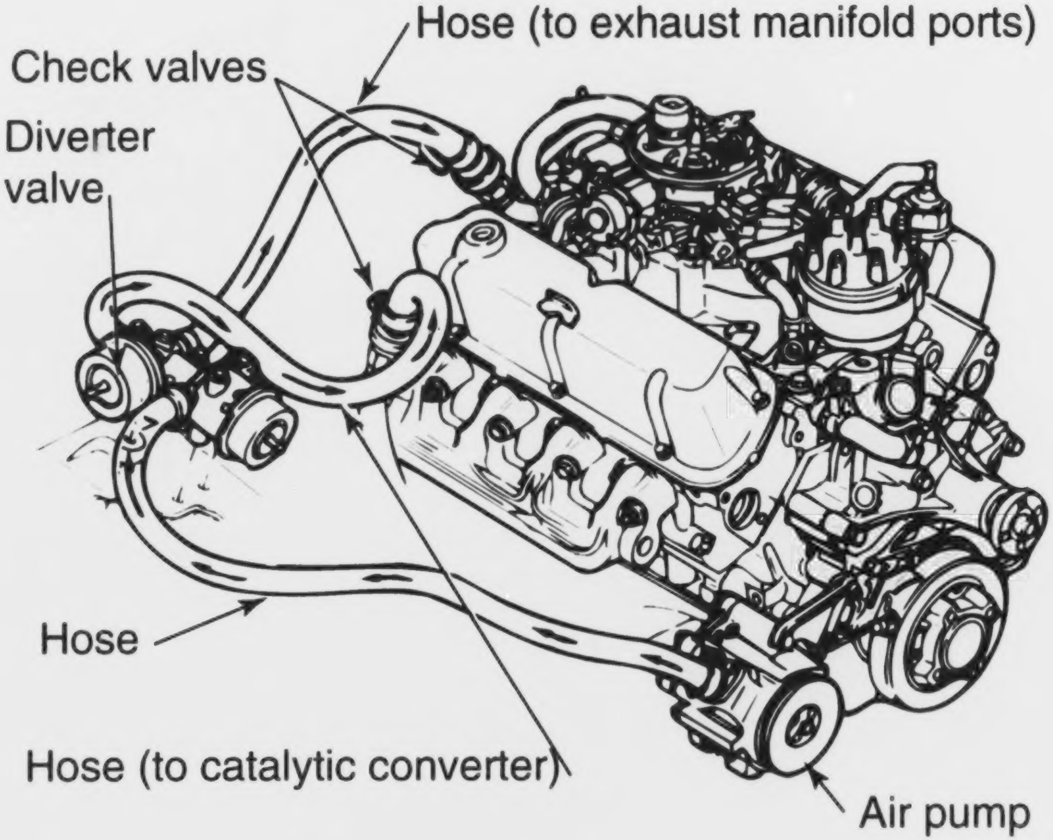
35. Take _____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

May be photocopied for student use.

Pump Type Air Injection System Components


Hose (to exhaust manifold ports)
Check valves
Diverter valve
Hose
Hose (to catalytic converter)
Air pump

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WRITTEN TEST

SERVICING AIR INJECTION SYSTEMS

13

Name ______________________ Date __________ Score ____

OBJECTIVE 1

State the function of an air injection system. Write your answer in the space provided.

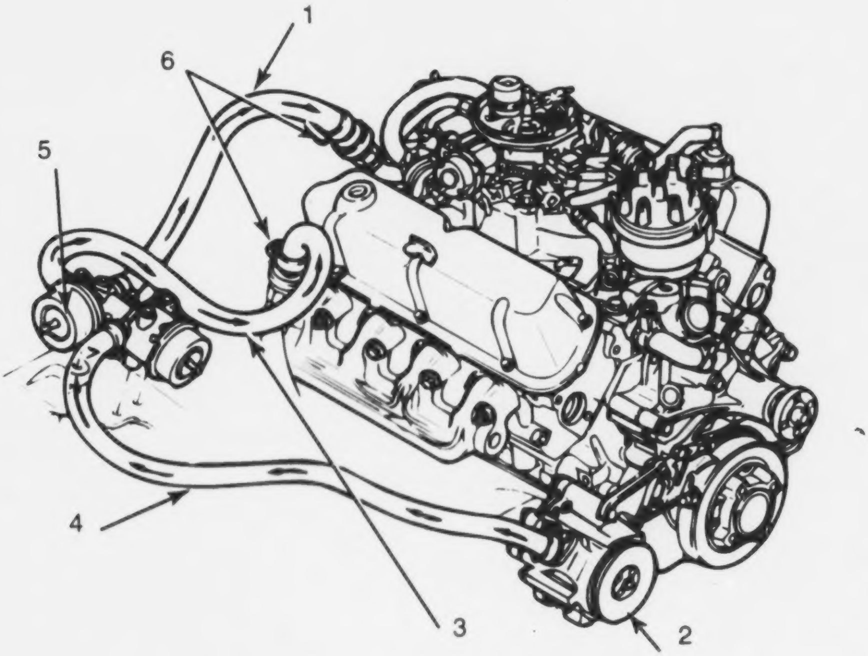
____

____

____

OBJECTIVE 2

Label the components of a pump type air injection system indicated on an illustration. Put the name of the part indicated in the corresponding blank.



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1. ____

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

OBJECTIVE 3

Describe the operation of a pump type air injection system. Write your description in the space provided.

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____

____

OBJECTIVE 4

Match the names of the parts of a pump type air injection system to descriptions of their functions. Write the correct letter in each blank.

A. air pump
B. check valve
C. diverter valve

_____ 1. Forces air at low pressure to the diverter valve

_____ 2. Switches the flow of fresh air to either the exhaust manifold, the catalytic converter, or the atmosphere as needed

May be photocopied for student use.

_____ 3. Prevents the hot exhaust gases from backing up in the system and entering and damaging the upstream components

OBJECTIVE 5 **Describe the operation of a pulse air injection system.** Write your description in the space provided.

OBJECTIVE 6 **Evaluated on Job Sheet 1.**

OBJECTIVE 7 **Evaluated on Job Sheet 2.**

OBJECTIVE 8 **Evaluated on Job Sheet 3.**

OBJECTIVE 9 **Evaluated on Job Sheet 4.**

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OBJECTIVE 10 **Evaluated on Job Sheet 5.**

OBJECTIVE 11 **Evaluated on Job Sheet 6.**

May be photocopied for student use.

HANDOUT

SERVICING AIR INJECTION SYSTEMS

13

Air Injection System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Backfire during deceleration	Defective diverter valve	Test and replace diverter valve
	Defective check valve	Inspect and replace if needed
No air supply	Loose or damaged drive belt	Tighten or replace drive belt
	Leaking hoses or hose connections	Tighten or replace hoses/connections
	Leaking diverter valve	Test and replace diverter valve
	Check valve stuck	Test and replace check valve
	Leaking pressure relief valve	Test and replace relief valve
Excessive drive belt noise	Loose belt 3	Tighten or replace belt
	Seized pump	Replace pump
	Loose pulley	Replace pulley
Excessive system noise (knocking, hissing, or rumbling)	New pump	Drive vehicle 20 miles to break in new pump (Some models may take up to 500 miles to correct.)
	Leaking hose	Tighten or replace hose
	Loose, pinched, or kinked hose	Reassemble, straighten, or replace hose and clamps as required
Excessive system noise	Defective check valve	Replace check valve
	Loose or broken brackets or bolts	Replace and tighten brackets or bolts
	Defective pump	Replace pump

Air Injection System Diagnosis Chart (continued)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Excessive system noise (cont.)	Inoperative bypass valve	Test bypass valve
	Restricted or bent pump outlet fitting	Inspect fitting and remove blockage; replace bent fittings
Excessive pump noise (chirping, squeaking, or ticking)	Loose pulley or mounting bolts or worn or damaged pump	Check air noise injection system for wear, loose or damaged pulley or mounting bolts; make necessary corrections
	Loose or leaking hose	Locate leak; replace hose or tighten connection

LAP
SHEET

SERVICING HEATED AIR INDUCTION SYSTEMS

14

Name ______________________________

Check the blank as you complete each step.

1. **Take** _____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read** _____ the introduction, unit objective, and specific objectives.
3. **Do** _____ the focus assignments.
4. **Stop** _____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study** _____ the Information Sheet, objectives 1 and 2.
6. **Ask** _____ your instructor to point out the parts of a heated air induction system on an actual vehicle.
7. **Study** _____ the Information Sheet, objective 3.
8. **Ask** _____ your instructor to explain how the parts of a heated air induction system shown in Figure 1 work.
9. **Study** _____ the introduction to Job Sheet 1.
10. **Ask** _____ your instructor why it is best to inspect and test this system on an annual basis.
11. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.
12. **Practice** _____ the procedures demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

May be photocopied for student use.

13. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

14. **Study** _____ the introduction to Job Sheet 2.

15. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

16. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

17. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

18. **Study** _____ the introduction to Job Sheet 3.

19. **Ask** _____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

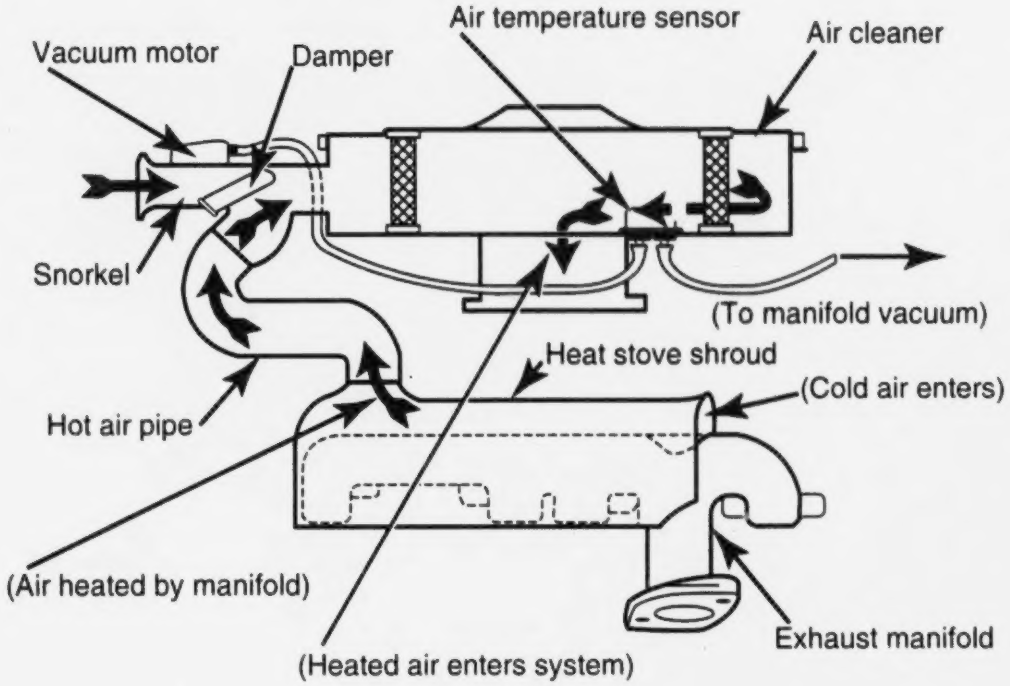
20. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

21. **Stop** _____ and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor's recommendations.

22. **Take** _____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

May be photocopied for student use.

Parts of a Heated Air Induction System


Air temperature sensor
Air cleaner
Vacuum motor
Damper
Snorkel
(To manifold vacuum)
Heat stove shroud
(Cold air enters)
Hot air pipe
(Air heated by manifold)
Exhaust manifold
(Heated air enters system)

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WRITTEN TEST

SERVICING HEATED AIR INDUCTION SYSTEMS

14

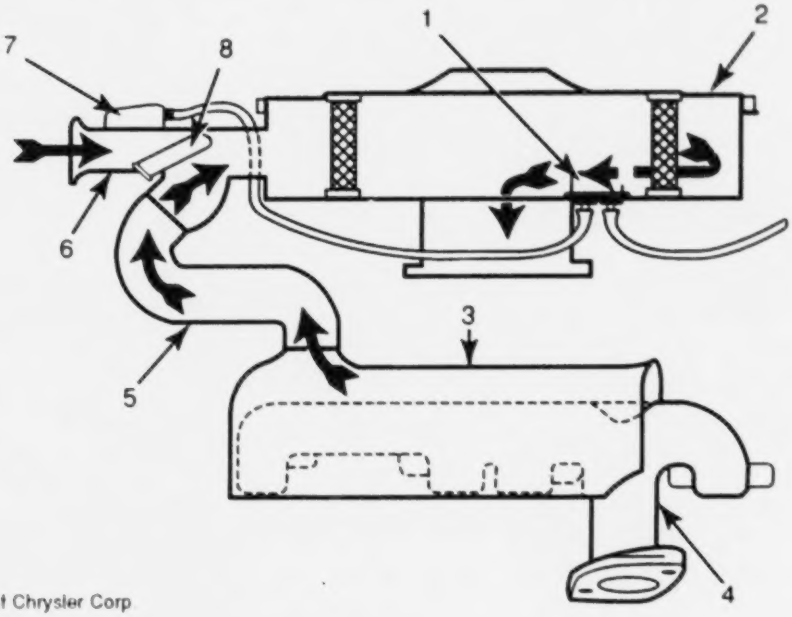
Name ______________________ Date __________ Score ____

OBJECTIVE 1

State the function of a heated air induction system. Write your answer on the lines provided.

OBJECTIVE 2

Label the parts of a heated air induction system indicated on an illustration. Write the name of each designated part in the corresponding blank following the illustration.



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May be photocopied for student use

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

OBJECTIVE 3 **Describe the operation of a heated air induction system.** Write your description on the lines provided.

____

____

____

____

____

____

____

____

____

____

OBJECTIVE 4 **Evaluated on Job Sheet 1.**

OBJECTIVE 5 **Evaluated on Job Sheet 2.**

OBJECTIVE 6 **Evaluated on Job Sheet 3.**

May be photocopied for student use.

HANDOUT

SERVICING HEATED AIR INDUCTION SYSTEMS

14

Heated Air Induction System Diagnosis Chart

The most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Cold engine runs rough or hesitates when idling.	Vacuum motor damper closed to heated air induction	Test vacuum motor. Replace if necessary. Check vacuum going to motor. Replace air temperature sensor if necessary. Inspect hoses for cracks, kinks, or leaks. Check for loose connections. Replace hoses if necessary.
	Hot air pipe not properly connected	Make sure hot air pipe is connected properly.
Hot engine displays a lack of power.	Vacuum motor damper open to heated air induction	Test vacuum motor. Replace if necessary. Test air temperature sensor. Replace if necessary. Inspect hoses for cracks, kinks, and leaks. Replace if necessary.
Cool air or no air passing through the hot air pipe.	Hot air pipe damaged or obstructed	Inspect hot air pipe for kinks, obstructions, tears, or other damage. Replace if necessary.
	Heat stove shroud damaged	Inspect heat stove shroud for rust, holes, or cracks. Replace if necessary.

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LAP SHEET

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

15

Name ______________________________

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read** ____ the introduction, unit objective, and specific objectives.
3. **Do** ____ the focus assignments.
4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study** ____ the Information Sheet, objectives 1 and 2.
6. **Ask** ____ your instructor to explain the operation of the heat chamber in a manifold heat control system.
7. **Review** ____ the function of an intake manifold.
8. **Study** ____ the Information Sheet, objectives 3, 4, and 5.
9. **Ask** ____ your instructor to discuss the location and operation of the manifold heat control systems shown in Figures 1-3.
10. **Study** ____ the introduction to Job Sheet 1.
11. **Ask** ____ your instructor to show you manifold heat control systems in several makes and models of vehicles.
12. **Ask** ____ you instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

May be photocopied for student use.

13. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

14. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

15. **Study** _____ the introduction to Job Sheet 2.

16. **Ask** _____ you instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

17. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

18. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

19. **Study** _____ introduction to Job Sheet 3.

20. **Ask** _____ your instructor to show you a manifold heat control valve on several makes and models of vehicles.

21. **Ask** _____ you instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

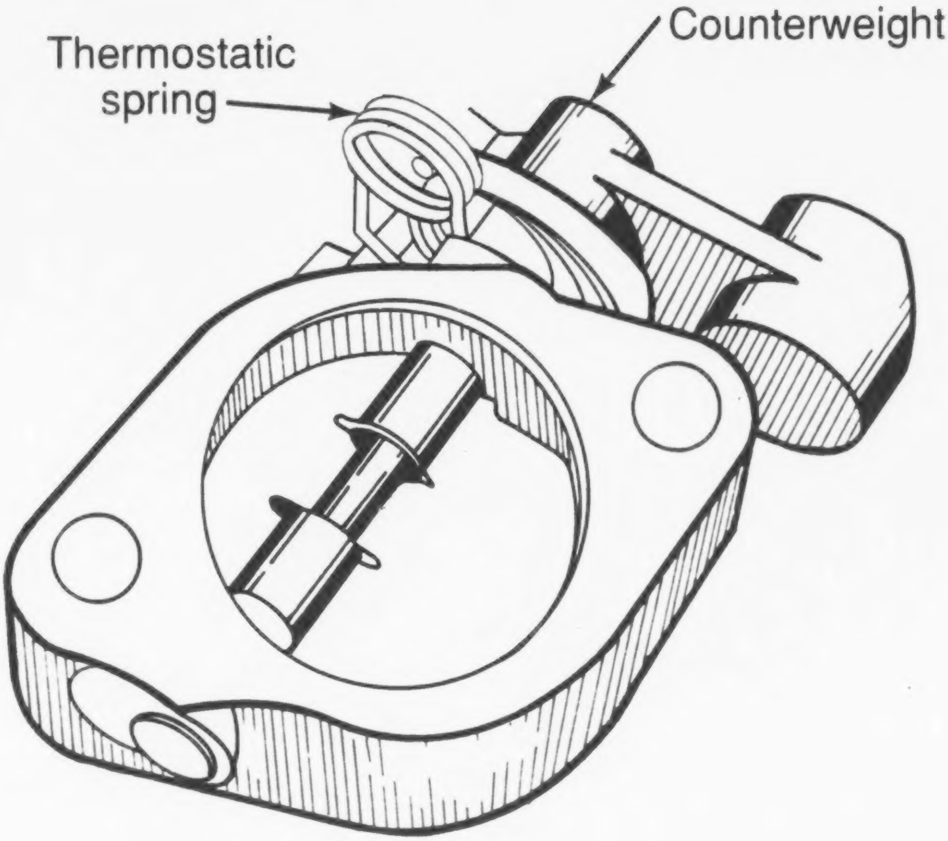
22. **Practice** _____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

23. **Stop** _____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

24. **Take** _____ the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

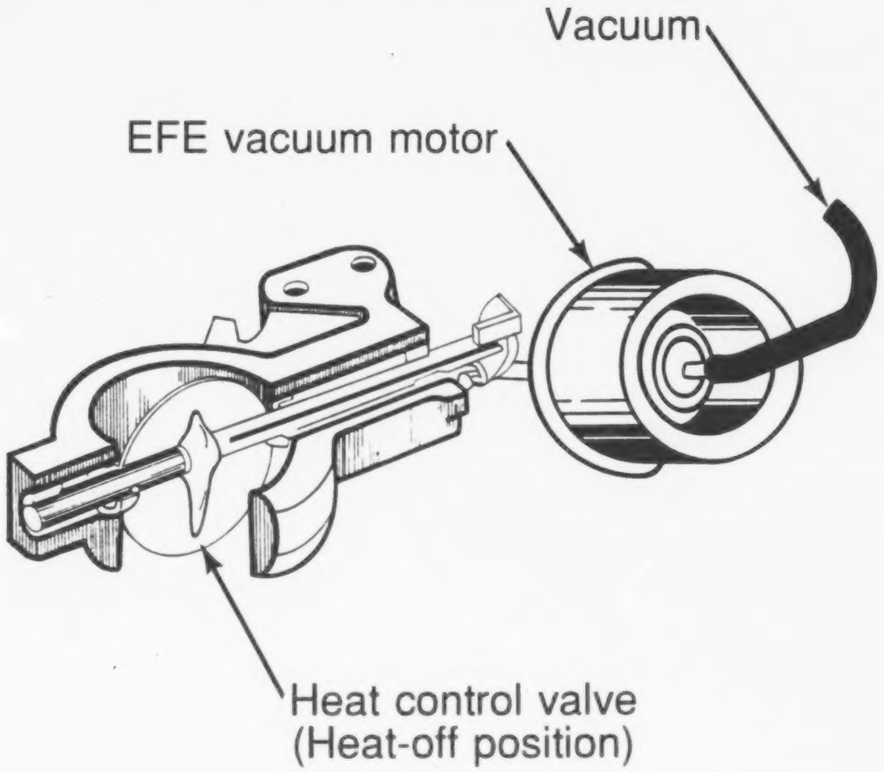
May be photocopied for student use

Mechanical Type Heat Control Valve System


Thermostatic spring
Counterweight

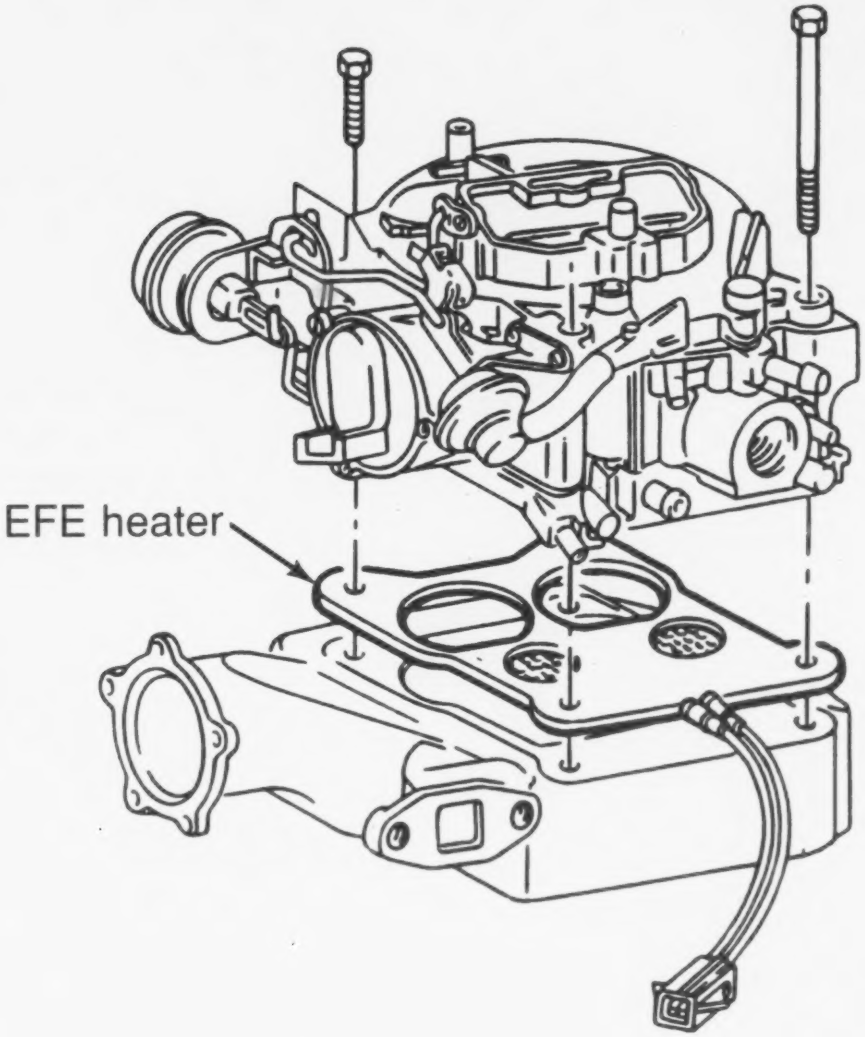
May be photocopied for student use.

Early Fuel Evaporation (EFE) Vacuum Type System with a Thermal Vacuum Switch


Vacuum
EFE vacuum motor
Heat control valve
(Heat-off position)

May be photocopied for student use.

Early Fuel Evaporation (EFE) Electrical Grid Type System



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WRITTEN TEST

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

15

Name ______________________ Date ________ Score ___

OBJECTIVE 1

State the function of a manifold heat control system. Write a sentence on the lines below which states the function of a manifold heat control system.

____

____

____

____

OBJECTIVE 2

Describe how the manifold heat control system usually achieves its function. Write a sentence on the lines below which describes how the manifold heat control system usually achieves its function.

____

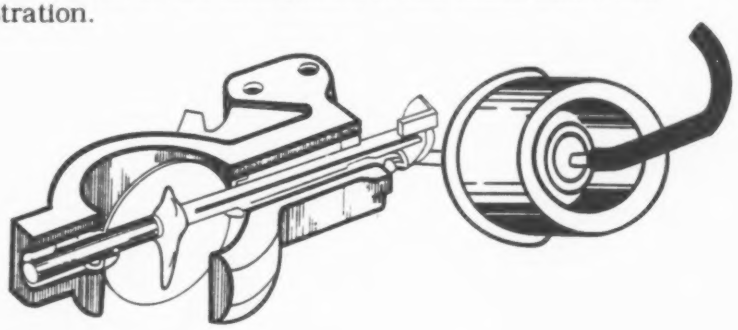
____

____

____

OBJECTIVE 3

Name the types of manifold heat control systems shown in illustrations. Write the name of the type of manifold heat control system shown in the illustration in the blank below the illustration.



1. Type of system ______________________________

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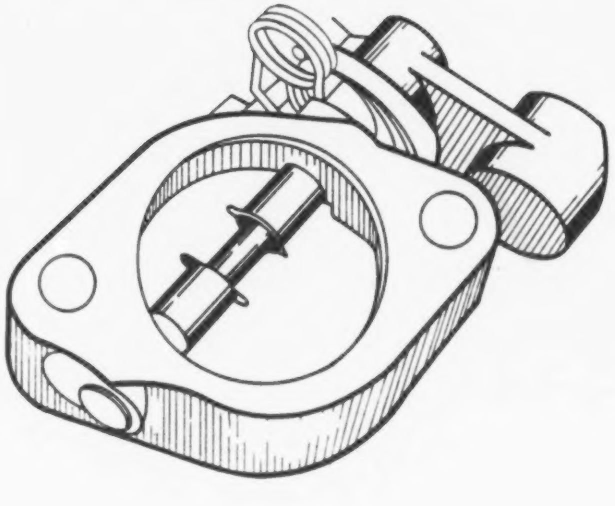
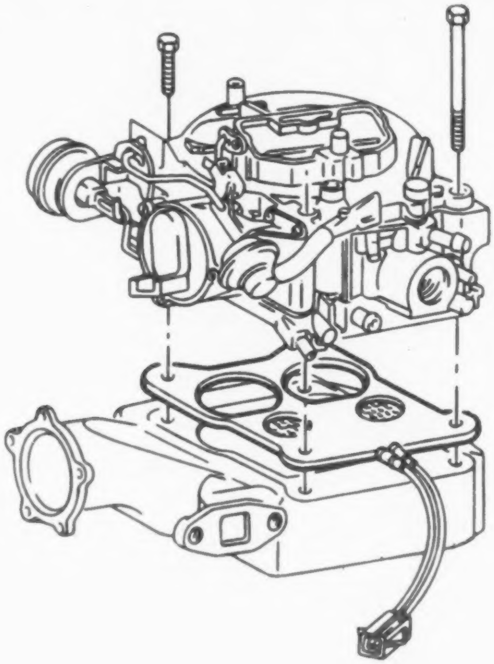


2. Type of system ____________________



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3. Type of system ____________________

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OBJECTIVE 4

State the location where each type of manifold heat control system is installed. Write the location where each type of manifold heat control system is installed on the lines under the name of the type of system.

1. early fuel evaporation (EFE) vacuum type system with a thermal vacuum switch.

   ____

   ____

2. mechanical type heat control valve system

   ____

   ____

3. early fuel evaporation (EFE) electric grid type system

   ____

   ____

OBJECTIVE 5

Match the names of types of manifold heat control systems to descriptions of their operation. Write the letter of the answer on the blank line provided beside the number of the description.

A. mechanical type heat control valve system
B. early fuel evaporation (EFE) electric grid type system
C. early fuel evaporation (EFE) vacuum type with a thermal vacuum switch

_____ 1. Uses vacuum and a vacuum motor controlled by a thermal vacuum switch to operate the heat control valve

_____ 2. Uses an electrical heating element, or *grid* to heat the air-fuel mixture as it enters the intake manifold.

_____ 3. Uses a large counterweight and a bimetal thermostatic spring to control the position of the heat control valve

OBJECTIVE 6

Evaluated on Job Sheet 1.

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OBJECTIVE 7 **Evaluated on Job Sheet 2.**

OBJECTIVE 8 **Evaluated on Job Sheet 3.**

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Manifold Heat Control System Diagnosis Chart

Most probable causes are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Cold engine stalls, slow to warm up, flat spots on acceleration, rough idles	Heat control valve stuck in the heat off position	Move the heat control valve by hand to free it or tap on it gently with a hammer. Lubricate the heat control valve. Inspect the thermal vacuum switch and replace if needed.
Engine overheats, denotation occurs	Heat control valve stuck in heat on position	Move the heat control valve by hand to free it or gently tap on it with a hammer. Lubricate the heat control valve. Inspect the thermal vacuum switch and replace if needed.
Engine noise	Crack or leak in the manifold floor, heat control valve, loose hose connection, or cracked gasket	Check, replace, or repair manifold floor, heat control valve, loose hose connection, or cracked gasket.

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LAP SHEET

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

Name ____________________

Check the blank as you complete each step.

1. **Take** ____ the pretest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.
2. **Read** ____ the introduction, unit objective, and specific objectives.
3. **Do** ____ the focus assignments.
4. **Stop** ____ and have your instructor evaluate your work from the focus assignment. After your work has been evaluated, follow your instructor's recommendations.
5. **Study** ____ the Information Sheet, objective 1.

Optional: Experience ____ vaporization by dabbing rubbing alcohol on your hand and observing it as it evaporates from the warmth of your hand.

6. **Study** ____ the Information Sheet, objectives 2 and 3.
7. **Ask** ____ your instructor to explain the functions of the parts of a fuel vapor control system as you look at Figure 1.
8. **Examine** ____ parts of a fuel vapor control system.
9. **Study** ____ the Information Sheet, objective 4.
10. **Study** ____ the introduction to Job Sheet 1.

Optional: Examine ____ fuel tank caps from pre-emission and post-emission regulation vehicles. Note the difference in cap design.

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11. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 1. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

12. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

13. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

14. **Study** ____ the introduction to Job Sheet 2.

15. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 2. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

16. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

17. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

18. **Study** ____ the introduction to Job Sheet 3.

19. **Ask** ____ your instructor to demonstrate the guidelines and procedures in Job Sheet 3. Use the appropriate service manual to follow along. Pay careful attention to any guidelines, cautions, and warnings.

20. **Practice** ____ the procedures demonstrated by your instructor. Use the appropriate service manual as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

21. **Stop** ____ and have your instructor evaluate your work from the appropriate service manual. After your work has been evaluated, follow your instructor's recommendations.

22. **Study** ____ the introduction to the Assignment Sheet.

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23. Complete	____	the Assignment Sheet.
24. Stop	____	and have your instructor evaluate your work from the Assignment Sheet. After your work has been evaluated, follow your instructor's recommendations.
25. Take	____	the posttest provided by your instructor. Have your instructor evaluate your completed test. After your test has been evaluated, follow your instructor's recommendations.

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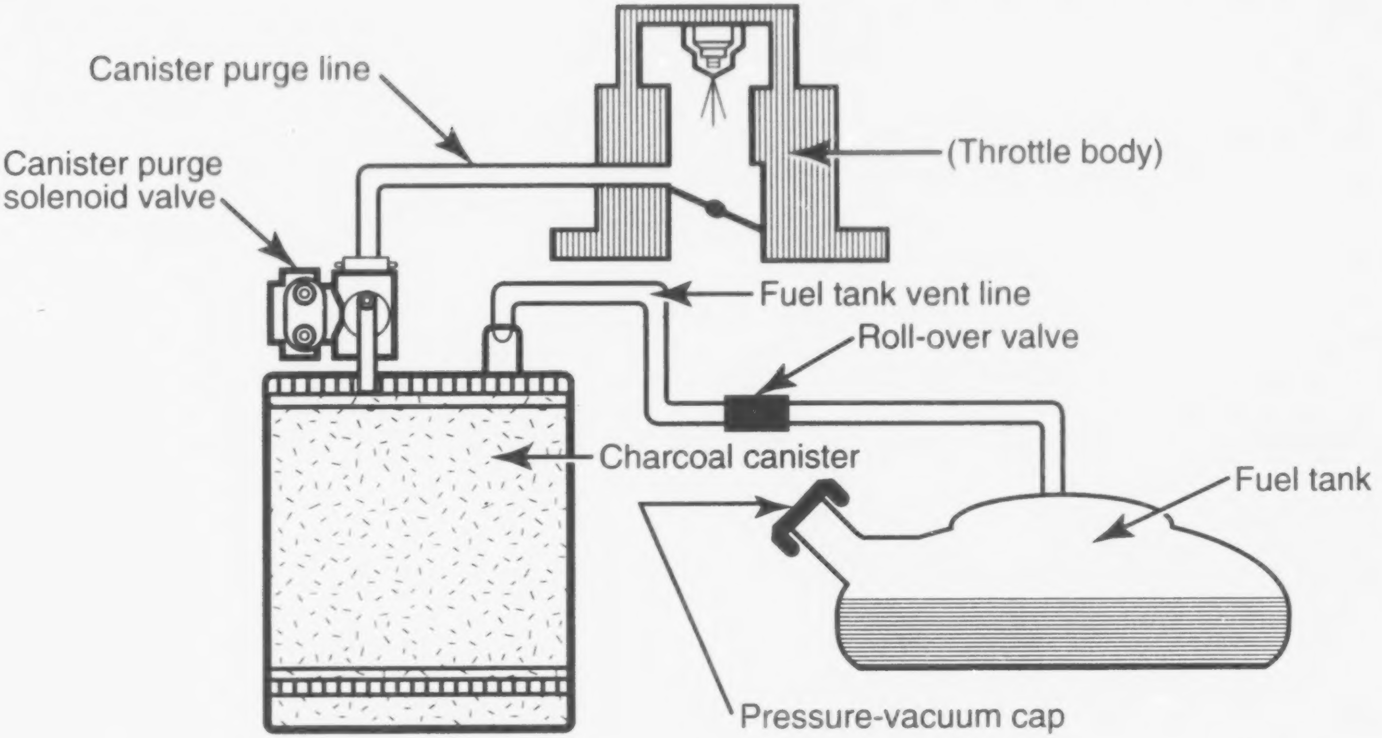
Parts of a Fuel Vapor Control System


Canister purge line
Canister purge solenoid valve
(Throttle body)
Fuel tank vent line
Roll-over valve
Charcoal canister
Fuel tank
Pressure-vacuum cap

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WRITTEN TEST

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

Name ______________________ Date __________ Score ____

OBJECTIVE 1

State the function of a fuel vapor control system. Write your answer in the space provided.

____

____

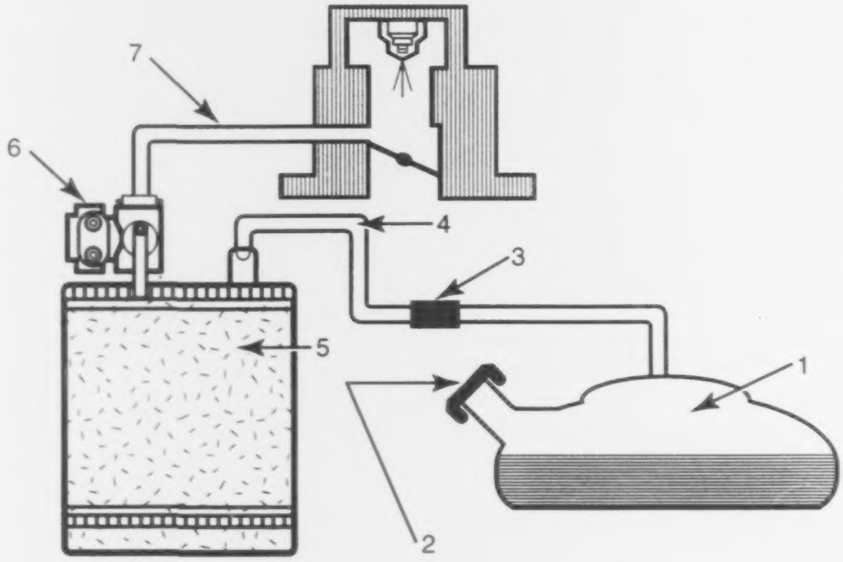
____

____

____

OBJECTIVE 2

Label the parts of a fuel vapor control system indicated on an illustration. Write the names of the parts indicated in the corresponding blanks provided beneath the illustration.



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1. ______________________________

2. ______________________________

3. ______________________________

4 ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

OBJECTIVE 3

Match the names of the parts of a fuel vapor control system to descriptions of their functions. Put the letter of the correct term in the blank in front of the description.

A. canister purge line
B. canister purge solenoid valve
C. charcoal canister
D. fuel tank
E. fuel tank vent line
F. pressure-vacuum cap
G. roll-over valve

_____ 1. Holds the fuel supply for the vehicle

_____ 2. Prevents liquid fuel from entering the fuel vent line if the vehicle is turned upside down

_____ 3. Responds to the engine computer's direction to open or close the canister purge line

_____ 4. Carries stored fuel vapors from the charcoal canister into the engine intake manifold

_____ 5. Stores fuel vapors from the fuel tank and/or the intake manifold

_____ 6. Carries fuel vapors from the fuel tank into the charcoal canister

_____ 7. Prevents fuel vapors from the fuel tank from entering the atmosphere

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OBJECTIVE 4 **Describe the operation of a fuel vapor control system.**

OBJECTIVE 5 **Evaluated on Job Sheet 1.**

OBJECTIVE 6 **Evaluated on Job Sheet 2.**

OBJECTIVE 7 **Evaluated on Job Sheet 3.**

OBJECTIVE 8 **Evaluated on the Assignment Sheet.**

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SERVICING FUEL VAPOR CONTROL SYSTEMS

Vehicle Emissions

History

During the 1950s the federal government made a study of air pollution. The findings showed that vehicle emissions created by the internal combustion engine created 45% of all air pollutants. As a result of this study, the legislature passed the first Clean Air Act in an effort to improve air quality. All the vehicle emission controls that exist today are a result of vehicle manufacturers' efforts to comply with this and subsequent federal and state legislation. Many of the emission controls have the added value of improving vehicle performance and fuel efficiency.

Combustion By-Products

Vehicle fuel is primarily made up of hydrogen (H) and carbon (C). Vehicle fuel delivery systems are designed to deliver an air-fuel mixture (AFR) as close to the ideal ratio as possible. The best combustion ratio for gasoline-powered internal combustion engines is 14.7 pounds of air to 1 pound of fuel. If this ideal mixture is delivered and all vehicle components are working perfectly, the vehicle will have an exhaust by-product made up of carbon dioxide (CO_2), water (H_2O), and heat. This result, however, is reached only under ideal conditions. Because vehicles operate under many different conditions such as changing air temperatures, changing loads, or defective and misadjusted engine parts, undesirable pollutants such as hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), sulphur dioxide (SO_2), and soot are frequently produced. A 4-gas analyzer, sometimes called an *exhaust gas analyzer*, analyzes the gases found in a vehicle's exhaust. The results of such an analysis can be an extremely valuable tool in diagnosing problems related to vehicle performance, fuel economy, and emissions.

Hydrocarbon (HC)

HC is unburned fuel which results from incomplete combustion. Anything which causes incomplete combustion, such as engine misfire, rich or lean fuel mixture, or poor mechanical condition of the engine, will result in a high HC reading on the 4-gas analyzer. Hydrocarbon in the exhaust is measured in parts per million (ppm). Compare the ppm of hydrocarbon to the measured air-fuel

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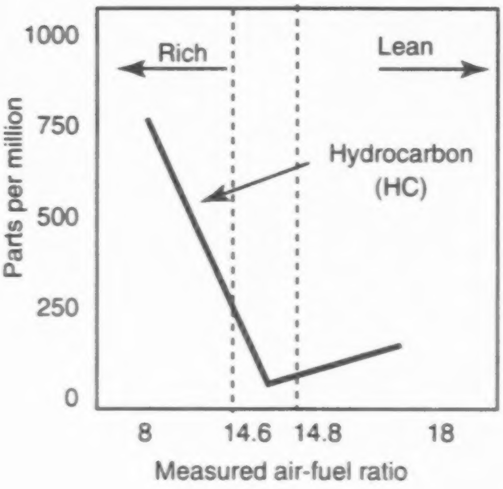
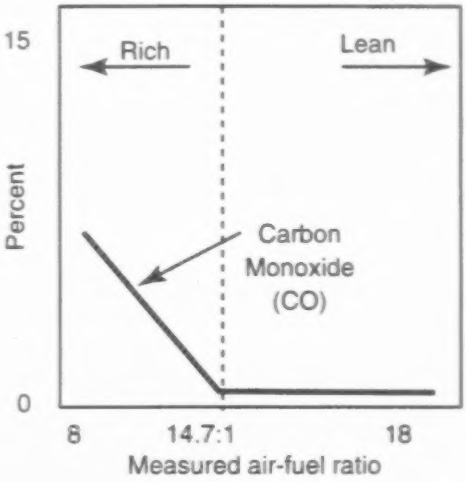
ratio. As the AFR goes from rich to lean, the HC goes from high ppm to just a few ppm at 14.7:1. The reason HC goes up is because the AFR is too lean for complete combustion. Use the chart to the right to make a comparison of HC to measured air-fuel ratio. See Handout 3.



☑ **NOTE:** A *lean* air-fuel mixture is one which has more than 14.7 pounds of air per pound of fuel. A *rich* air-fuel mixture is one which has less than 14.7 pounds of air per pound of fuel. Excessively lean mixtures can overheat the combustion chambers and increase the potential for internal engine damage. Excessively rich mixtures can cause poor mileage, fouled spark plugs, and increased engine wear.

Carbon Monoxide (CO)

Carbon monoxide is another by-product of incomplete combustion of the air-fuel mixture. A rich AFR, lacking in oxygen, will cause a high CO reading on the 4-gas analyzer. CO is at its lowest when the AFR is 14.7:1. CO level is the best indicator of a malfunction in the components that control the air-fuel ratio — the carburetor, fuel injection system, or any fuel delivery problem. See Handout 4.



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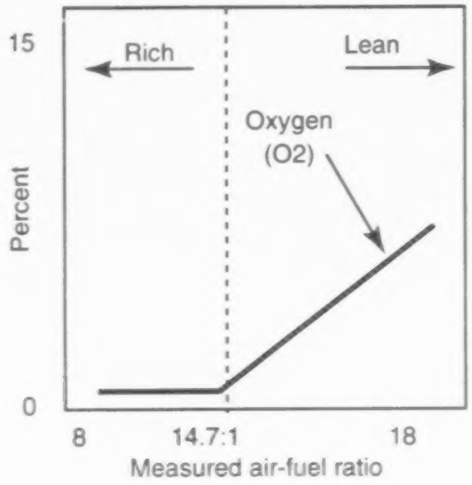
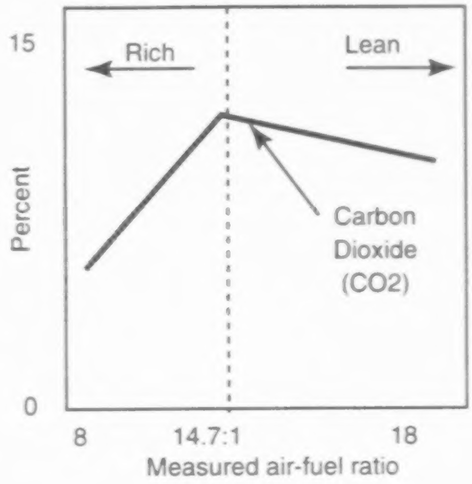
Oxygen (O_2)



Oxygen, necessary for combustion, is measured in percent (%) of the volume of the exhaust. The oxygen content of the atmosphere is about 21%. The oxygen content of the exhaust gas indicates if the fuel in the combustion chamber is using all the available oxygen in the air-fuel mixture. A lean air-fuel mixture causes the O_2 reading of the 4-gas analyzer to be high. A rich mixture causes a low O_2 reading. See Handout 5.

Carbon Dioxide (CO_2)



Carbon dioxide, a favorable by-product of combustion, is measured in percent of volume of the exhaust. As combustion efficiency increases, the CO_2 reading on the 4-gas analyzer becomes higher. The CO_2 percentage is an excellent reference that can help determine how efficiently the engine is performing. A CO_2 reading on the 4-gas analyzer below 10% is an indication of an engine that is running poorly. A CO_2 of above 11% is an indication of an engine that is running efficiently.

Some states are beginning to use a 5-gas analyzer. In addition to HC, O_2, CO, and CO_2, the 5-gas analyzer also monitors nitrogen oxides (NO_x). The presence of nitrogen oxides is controlled by the EGR system, the ignition timing control system, the combustion chamber components, and the engine cam. Federal requirements will make use of the 5-gas analyzer necessary in the near future.

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HANDOUT 2

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

Exhaust Gas Analysis Parameters for HC, CO, CO_2, and O_2

Condition	Gases	Idle		1500 RPM		2500 RPM	
		Converter	No Converter	Converter	No Converter	Converter	No Converter
Normal	**HC** (ppm)	0 - 150	75 - 250	0 - 135	50 - 200	0 - 75	25 - 150
	CO (%)	1 - 1.5	.5 - 3.0	0 - 1.1	.5 - 2.0	0 - .8	.1 - 1.5*
	CO_2 (%)	10 - 12	10 - 12			11 - 13	11 - 13
	O_2 (%)	.5 - 2.0	.5 - 2.0	.5 - 2.0	.5 - 2.0	.5 - 1.25	.5 - 2.0
Rich Mixture	**HC** (ppm)	0 - 150	75 - 250	0 - 135	50 - 200	0 - 75	0 - 100
	CO (%)	Above 3.0	Above 4.0	Above 3.0	Above 3.0	Above 3.0	Above 3.0
	CO_2 (%)	8 - 10	8 - 10			9 - 11	9 - 11
	O_2 (%)	0 - .5	0 - .5	0 - .5	0 - .5	0 - .5	0 - .5
Lean Mixture	**HC** (ppm)	0 - 150	75 - 250	0 - 135	50 - 200	0 - 75	0 - 100
	CO (%)	0 - 1.0	0 - 1.0	0 - .8	0 - .9	0 - .25	0 - .75
	CO_2 (%)	8 - 10	8 - 10			9 - 11	9 - 11
	O_2 (%)	1.5 - 3.0	1.5 - 3.0	1.0 - 2.5	1.0 - 2.5	1.0 - 2.0	1.0 - 2.0
Lean Misfire	**HC** (ppm)	50 - 850	400-1200	50 - 850	400-1200	50-750	400-1200
	CO (%)	0 - .3	0 - .75	0 - .3	0 - .75	0 - .3	0 - .75
	CO_2 (%)	5 - 9	5 - 9			6 - 10	6 - 10
	O_2 (%)	4 - 9	4 - 9	4 - 9	2 - 7	2 - 7	2 - 7
Misfire	**HC** (ppm)	50 - 850	over 1000	50 - 850	over 1000	50 - 750	over 1000
	CO (%)	.1 - 1.5	.5 - 3.0	0 - 1.1	.5 - 2.0	0 - .8	.1 - 1.5
	CO_2 (%)	6 - 8	6 - 8			8 - 10	8 - 10
	O_2 (%)	4 - 12	5 - 12	4 - 12	5 - 12	4 - 12	5 - 12

Exhaust readings are taken with the air injection system disabled.
* Normal CO reading for a 4 cylinder vehicle is 3%.

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Hydrocarbon (HC) Exhaust Level Diagnosis

Some of the controls which affect hydrocarbon emissions are: the engine design, closed loop PVC system, components involved in combustion (i.e. valves, cylinders, rings, etc.), cam, exhaust manifold, catalytic converter, components involved in air-fuel delivery, air injection system, fuel vapor control system, heated air induction system, carburetor and fuel injection system.

Problems which can cause abnormal hydrocarbon levels in exhaust gas:

Rich Mixture

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
HC high during warmup	Faulty cold start enrichment system	Inspect and repair choke or cold start enrichment system.
HC high during warmup and vehicle stalls on startup	Manifold heat control defective or stuck open Cold air entering engine	Service manifold heat control system. Check for problem with the air induction system.
HC high after warmup and above idle	No air from the air injection system	Inspect and repair/replace defective air pump, belt, hoses, diverter valve.
HC high and a rough idle	Defective PCV valve Problem in the fuel vapor control system (plugged or gasoline-soaked charcoal canister or faulty purge valve)	Clean or repair PCV system. Check for contaminated oil in engine. Inspect and repair/replace affected components.

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CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
HC high at idle and poor fuel mileage	Leaking fuel injector or idle mixture of carburetor	Repair/replace the fuel injector or carburetor.
	Restricted air cleaner	Replace air cleaner filter.
HC high after catalytic converter reaches operating temperature	Defective catalytic converter	Replace catalytic converter.
HC high, low compression	Internal engine defect such as rings, valves, cam	Repair engine (rings, valves, cam).
HC high, misfire	Faulty spark plug	Replace spark plug.
	Faulty spark plug wire	Replace spark plug wire.
	Over-advanced timing	Correct timing.
	EGR valve stuck open	Repair/replace EGR valve.
HC high, poor fuel mileage and loss of power	Defective O_2 sensor	Replace O_2 sensor.
	Faulty MC (motor control) solenoid or injectors	Repair solenoid or injectors.
	Fuel pressure too high	Check for defective fuel pump or pressure regulator. Repair or replace as needed.
	Defective MAP sensor	Repair MAP sensor.
	Defective mass air flow sensor	Replace MAF sensor.
	Defective engine computer	Repair/replace engine computer.

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Carbon Monoxide (CO) Exhaust Level Diagnosis

Some of the controls which affect carbon monoxide emissions are: the catalytic converter, air injection system, O_2 sensor, ignition timing controls, and engine computer controls and sensors that control the fuel delivery system.

Problems which can cause abnormal carbon monoxide levels in exhaust gas:

Lean Mixture

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Low CO, lean misfire (If it is excessively lean, then HC will be high.)	Vacuum leaks Defective PCV valve hose	Repair vacuum leaks at intake manifold or lines. Repair vacuum hose to the PCV valve.
Low CO, hard cold starting, loss of power	Faulty fuel injectors or carburetor	Clean, repair, or replace fuel injectors or carburetor.
Low CO, loss of power at cruise and high speed	Defective fuel pump/restricted fuel filter or fuel regulator	Repair or replace fuel pump/regulator or fuel filter.
Low CO, check engine light on	Faulty O_2 sensor or engine computer	Replace O_2 sensor or engine computer.
Low CO, detonation	Defective EGR valve Loose PCV valve	Clean, repair, or replace EGR valve. Replace PCV valve.

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Oxygen (O_2) Exhaust Level Diagnosis

The two controls which affect the amounts of oxygen in the exhaust are the oxygen sensor and the air injection system. The oxygen sensor senses the amount of oxygen in the exhaust and sends a signal to the engine computer to adjust the air-fuel ratio (AFR). For most driving conditions, this ratio is 14.7 parts air to 1 part fuel. For example, if the engine misfires, the O_2 sensor will sense the excess oxygen in the exhaust and signal the engine computer to adjust the AFR to a richer mixture.

The air injection system supplies air to burn excess fuel in the exhaust. The normal O_2 in the exhaust of a vehicle operating with an air injection system is 4% or higher. If the air injection system is disabled, the O_2 will drop to .5% - 2%. (Most tests are made with the air injection system disabled.) High O_2 readings on the 4-gas analyzer means there is too much air in the combustion chamber; this indicates that the AFR is too lean. Low O_2 readings indicate there is not enough air in the combustion chamber to combine with HC for complete combustion; this indicates that the AFR is too rich. In both rich and lean conditions, where the O_2 is excessively high or excessively low, the CO_2 will always have a low reading on the 4-gas analyzer, because there will not be the proper amount of oxygen to mix with the HC.

Excessively Low O_2 -- the AFR is Too Rich

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Low O_2, engine stalls at idle	Restricted or defective PCV valve	Replace PCV valve.
Low O_2, idle is rough after warmup	Defective cold start enrichment system	Adjust or repair cold start enrichment system.
Low O_2, poor fuel mileage	Fuel pressure too high Restricted air cleaner	Repair or replace fuel regulator/pump. Replace air cleaner.

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Excessively High O_2 -- the AFR is Too Lean

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
High O_2, hard starting, rough idle	Vacuum leaks, intake, hoses	Repair vacuum leaks.
	Defective EGR system	Clean, repair, or replace.
High O_2, loss of power at high speed	Defective fuel injectors	Clean, repair, or replace fuel injectors.
	Low fuel pressure	Repair or replace fuel regulator or fuel pump.
	Restricted fuel filter	Replace fuel filter.
	Defective carburetor	Repair or replace carburetor.
High O_2, check engine light on	Defective O_2 sensor or engine computer	Replace O_2 sensor or engine computer.

Formula for calculating excessive O_2 with an engine misfire:

Air is approximately 21% oxygen. Divide 21% by the number of cylinders on the engine being tested. The O_2 reading on the 4-gas analyzer will increase by that percent.

EXAMPLE: One cylinder misfires on a four cylinder engine. Divide 21% by 4 = about 5%. Add 5% to a normal O_2 reading of .5% to 2% = Reading on 4-gas analyzer is approximately 5.5% to 7%.

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How Vehicle Emissions are Affected by Gasoline

To understand how gasoline affects vehicle emissions, you must understand that gasoline is not a single substance. It is a mixture of elements and compounds which vary widely in their physical and chemical properties. The gasoline mixture must be balanced to give good engine performance over a wide range of driving conditions. Gasoline quality is measured by the American Society for Testing and Materials (ASTM) and is rated based on the gasoline's Antiknock Index. This rating, the *octane*, is the number posted on the gasoline pump.

In the early 1980s, the Environmental Protection Agency (EPA) began to reduce the lead (tetra-ethyl-lead, a cheap octane booster) in gasoline in what has become a continuing effort to reduce harmful vehicle emissions. To maintain the level of octane necessary to operate modern engines, the petroleum industry mixes *oxygenates* with the gasoline. Most compounds found in gasoline are made up of hydrogen and carbon (HC). Oxygenates are made up of hydrogen, carbon, and oxygen. When you add oxygenates to the fuel, you are adding additional oxygen to the air-fuel mixture. This addition enables the gasoline to burn cleaner, reducing carbon monoxide (CO) in the exhaust. Some state laws require gasoline formulas sold in the state to contain higher levels of oxygenates in the fuel to reduce exhaust emissions.

Gasoline engines burn fuel that has been vaporized and introduced into the cylinders. Gasoline vaporizes quickly in warm weather and more slowly in colder weather. Because it is desirable that a vehicle's engine perform well in both cold weather and warm weather, gasoline manufacturers change the formula of gasoline in the winter months by adding highly flammable chemicals such as ethers and butane. These additives increase the gasoline's volatility, or ability of the gasoline to vaporize. By changing the formula, good combustion is maintained and emissions are kept low. During hot weather volatile additives are not desirable because if they were used, the fuel would vaporize in the fuel lines and cause engine performance problems.

A common problem often develops when a week or so of very warm weather occurs during the winter. The fuel, a winter formula, vaporizes in the fuel line causing low fuel pressure

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resulting in a lean air-fuel mixture. The lean air-fuel mixture causes a lean misfire. Lean misfire increases the level of hydrocarbon, increasing pollution and resulting in poor engine performance. During hot weather, if we have a day or week of very cool weather, the fuel, a summer formula, will have a hard time vaporizing while the engine is cold. This will cause hard starting and poor performance until the engine is at operating temperature. If the fuel doesn't mix properly into the air-fuel mixture, carbon monoxide (CO) will be high and all of the fuel will not burn in the combustion chamber, causing high levels of hydrocarbons (HC). Some of the oxygenates cause deposits to form on the fuel injectors and on the intake valves and ports. This causes power loss, performance problems, poor fuel economy, and high exhaust emissions. Also, when the vehicle is started cold, these deposits absorb fuel from the air-fuel mixture, causing hard starting and a lean operating condition until the vehicle warms up.

Although alcohols, butane, and ethers are the main additives used to oxygenate our fuels, gasoline manufacturers also use different chemicals such as ethanol, gasohol, methanol, and other octane enhancers to boost octane, lower emissions, and increase the volatility of the fuel. Because of oxyfuel mandates by the EPA, fuels of the future will include ethanol, methanol, compressed natural gas, propane, hydrogen, and a designer gasoline, reformulated with the environment in mind. Some of the present gasoline modifications that will be needed to meet future regulations are:

Change that needs to be made	Reason for change
reduction of benzene	toxic effect which causes cancer
reduction of olefins	photochemical reaction which causes smog formation
reduction of sulfur	causes acid rain
reduction of xylene	photochemical reaction which causes smog formation
reduction in fuel volatility	reduces evaporative emissions which result in smog formation
increase in oxygen content	reduces exhaust emission of carbon monoxide
redesign of the combustion chamber	to accept new fuel formulas

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Engine Performance Specialist

Student Workbook

Part 1

Developed by the
Curriculum and Instructional Materials Center
for the Division of **Trade and Industrial Education**
Oklahoma Department of Vocational and Technical Education

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OBJECTIVE SHEET

UNDERSTANDING ENGINE FUNDAMENTALS

1

INTRODUCTION

The four stroke cycle is the heart of the combustion engine, converting fuel to energy to keep the vehicle running. Timing is critical to maintaining optimum performance and efficiency while limiting the toxic substances produced in the exhaust. Timing that produces maximum power and fuel economy also produces higher levels of hydrocarbons and oxides of nitrogen. Emission control techniques are used to reduce the amount of toxic gases emitted into the atmosphere through the exhaust; specifically, hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x). In this unit you will learn the fundamental facts regarding the four stroke cycle, emission control, and safety hazards associated with combustion engines.

PREREQUISITE

NONE

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS

PREREADING:	Read the article, "The Charging System" in the December 1993 issue of *Hot Rod* magazine.
WRITING:	Write a short (one paragraph to one page) description of the causes and symptoms of fouled spark plugs.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. List safety hazards associated with engine performance work.
2. List automotive sources related to engine service which contain hazardous chemicals.
3. List the names of engine systems.
4. Describe the functions of engine systems.
5. List three elements that must be present in order for combustion to occur.
6. List the four strokes of an internal combustion engine in the order of their occurrence.
7. Using illustrations of cylinders, sketch the spark in the correct engine stroke.
8. Using illustrations of cylinders, sketch the piston in the correct position for each of the four engine strokes.
9. Using illustrations of cylinders, draw an arrow to indicate the direction of piston movement for each of the four engine strokes.
10. Using illustrations of cylinders, sketch the intake valve in the correct position for each of the four engine strokes.
11. Using illustrations of cylinders, sketch the exhaust valve in the correct position for each of the four engine strokes.
12. List the names of emission control systems.

INFORMATION SHEET

UNDERSTANDING ENGINE FUNDAMENTALS

1

OBJECTIVE 1

List safety hazards associated with engine performance work.

Required Activities/
Resources
– Discussion

Participate in a discussion of engine-related safety hazards.

- **cuts**

  ☑ **NOTE:** Sources – The engine and engine compartment contain many surfaces that could cause severe injury from cuts. Many of the tools you use can also cause serious cuts. Prevention – Cover sharp edges and be sure you are using the correct tool for the job. If you are working near a fan, disconnect the battery ground cable to the fan. Do not stand directly in line with a running fan.

- **electrical shock**

  ☑ **NOTE:** Sources – The battery, ignition, and starting system may cause shocks. Prevention – Turn off the ignition or disconnect the battery and remove all jewelry before working on these systems.

- **exposure to toxic chemicals**

  ☑ **NOTE:** Sources – Exhaust gases, leaded gasoline, solvents, antifreeze, battery acid, used motor oil, and chemicals used in cleaning compounds may cause a variety of problems. Prevention – Avoid inhaling fumes, swallowing these materials, or getting them on your skin or in your eyes.

- **muscle strains**

  ☑ **NOTE:** Sources – Engine components are very heavy and when you are working under the hood you are in an awkward position for any lifting. Prevention – Use the proper shop equipment or ask for help when you need to lift something heavy.

OBJECTIVE 2

Required Activities/
Resources
– Explanation

Optional Activities/
Resources in
Instructor's Guide

List automotive sources related to engine service which contain hazardous chemicals.

Listen as your instructor explains the chemical hazards which exist when working with engine systems.

- leaded gasoline
- battery acid
- antifreeze
- gum and carbon removal compounds
- solvents
- carburetor cleaners
- exhaust gases
- gasoline additives
- compounds used to free valve lifters

OBJECTIVE 3

List the names of engine systems.

- starting system
- ignition system
- fuel system
- lubrication system
- cooling system
- exhaust system
- charging system

☑ **NOTE:** These engine systems are needed to get the engine running and keep it running.

OBJECTIVE 4

Required Activities/
Resources
– Explanation
– Vehicle

Describe the functions of engine systems.

Listen to your instructor's explanation of the functions of the engine systems listed below.

Look at the components of different engine systems as your instructor points them out on an actual vehicle.

- **starting system** — starts the engine
- **ignition system** — provides the spark to burn the fuel
- **fuel system** — supplies fuel to the engine
- **lubrication system** — reduces friction and cleans the engine

- **cooling system** — cools the engine
- **exhaust system** — removes unburned fuel and exhaust from the engine
- **charging system** — provides electrical power to the ignition system and charges the battery

OBJECTIVE 5

List three elements that must be present in order for combustion to occur.

- fuel
- air
- heat

☞ **NOTE:** All three of these elements must be present *at the same time.*

OBJECTIVE 6

Required Activities/
Resources
– Transparency Master 1

Optional Activities/
Resources in
Instructor's Guide

List the four strokes of an internal combustion engine in the order of their occurrence.

Look at transparency 1 as your instructor explains what happens in the engine during each of the four strokes.

- intake
- compression
- power
- exhaust

☞ **NOTE:** These four strokes always follow each other in sequence throughout many repetitions. Once the exhaust stroke is complete, the sequence begins again with the next intake stroke.

OBJECTIVE 7

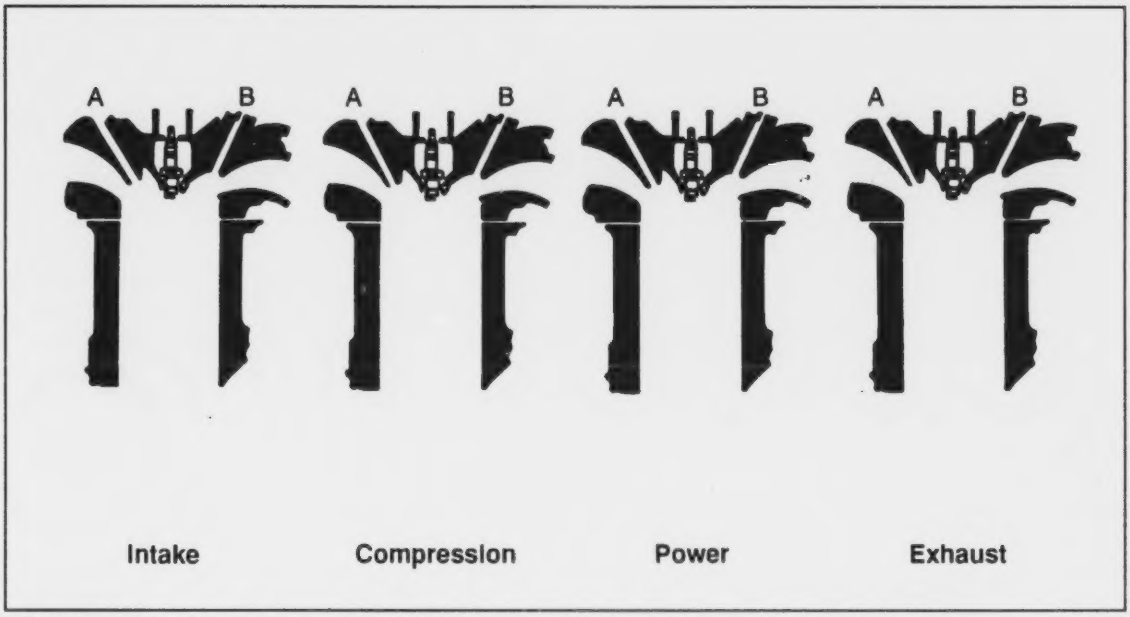
Required Activities/
Resources
– Explanation
– Transparency Master 2 or the Handout

Using illustrations of cylinders, sketch the spark in the correct engine stroke.

Listen as your instructor explains engine timing as it relates to the power stroke.

Use the Handout or transparency 2 to help you draw the spark in the correct engine stroke in Figure 1. After you are finished, have your instructor check your drawing.

FIGURE 1



☑ **NOTE:** Intake valves are labeled "A" and exhaust valves are labeled "B.

OBJECTIVE 8

Using illustrations of cylinders, sketch the piston in the correct position for each of the four engine strokes.

Required Activities/ Resources
- Explanation
- Transparency Master 3 or the Handout

Listen as your instructor explains the terms in the Words You Should Know box.

WORDS YOU SHOULD KNOW	
number one piston	the piston used to set the ignition timing. Check the vehicle's service manual for the location of the number one piston
top dead center (TDC)	when the number one piston is at the top of the compression stroke
cam timing	controls when the valves open, how long they stay open, the size of the opening, and when they close
ignition timing	controls when the spark fires. The vehicle's service manual specifies how many degrees before or after TDC the spark should fire

Use the Handout or transparency 3 to help you draw the piston in the correct position for each of the four engine strokes in Figure 1. After you are finished, have your instructor check your drawing.

OBJECTIVE 9

Required Activities/ Resources
- Transparency Master 4 or the Handout

Using illustrations of cylinders, draw an arrow to indicate the direction of piston movement for each of the four engine strokes.

☞ Use the Handout or transparency 4 to help you draw an arrow indicating the direction of piston movement for each of the four engine strokes shown in Figure 1. After you are finished, have your instructor check your drawing.

OBJECTIVE 10

Required Activities/ Resources
- Transparency Master 5 or the Handout

Using illustrations of cylinders, sketch the intake valve in the correct position for each of the four engine strokes.

☞ Use Handout 5 to help you the draw intake valve in the correct position for each of the four engine strokes down in Figure 1. After you finished, have your instructor check your drawing.

OBJECTIVE 11

Required Activities/ Resources
- Transparency Master 6 or the Handout

Using illustrations of cylinders, sketch the exhaust valve in the correct position for each of the four engine strokes.

☞ Use Handout or transparency 6 to help you draw the exhaust valve in the correct position for each of the four engine strokes shown in Figure 1. After you are finished, have your instructor check your drawing.

OBJECTIVE 12

Optional Activities/ Resources in Instructor's Guide

List the names of emission control systems.

- **air injection system**

  ☑ **NOTE:** The air injection system introduces fresh air into the exhaust manifold to continue combustion of fuel in the exhaust and convert some of the toxins to non-toxic chemical compounds.

- **exhaust gas recirculation system**

  ☑ **NOTE:** The exhaust gas recirculation (EGR) system reduces the amount of nitrogen oxide (NOx) a vehicle emits into the air by reducing the combustion temperature. It achieves this by allowing a small amount of exhaust gas to return through the intake manifold into the cylinders.

- **fuel vapor control system**

  ☑ **NOTE:** The fuel vapor control system prevents pollution and increases vehicle fuel economy by preventing fuel vapors from escaping directly into the atmosphere.

- **heated air induction system**

  ☑ **NOTE:** The heated air induction system improves engine performance and reduces emissions by decreasing engine warm-up time and keeping the temperature of the air entering the engine constant.

- **manifold heat control system**

  ☑ **NOTE:** The manifold heat control system heats the air in the intake manifold when the engine is cold. Heating the manifold increases fuel vaporization thereby decreasing HC and CO emissions, and facilitating more equal distribution of fuel to the cylinders.

- **positive crankcase ventilation system**

  ☑ **NOTE:** The positive crankcase ventilation (PCV) system reduces vehicle emissions and protects engine parts from sludge by removing fuel and water vapors (blow-by) from the crankcase.

OBJECTIVE SHEET

SERVICING STARTING AND CHARGING SYSTEMS

2

INTRODUCTION

A vehicle's starting and charging systems depend upon one another to allow the engine to start. During cranking, the battery supplies electrical energy to the starter motor. The starter motor converts this electrical energy into the mechanical energy needed to crank the engine fast enough to run. Once the engine is running, the charging system converts mechanical energy from the engine into electrical energy to recharge the battery. It is important for the Engine Performance Technician to understand the interdependence of starting and charging systems and to be able to correctly diagnose, service, and repair any abnormal condition.

PREREQUISITE

Unit 1, "Understanding Engine Fundamentals"

FOCUS ASSIGNMENTS

Reading Comprehension

- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language

- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition

- Use complete sentences

FOCUS ASSIGNMENTS	
PREREADING:	Read about how to keep an automobile battery in working order in John Kirk's article, "Keeping Batteries Charged," in *Home Mechanix* magazine, October 1992, pp. 32 and 36.
WRITING:	Write a short (one page) description of the charging system, particularly including ways to detect potential problems before they occur. Include any measures that can be taken to prevent excessive drain on the battery.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. List safety rules for working with automobile batteries.
2. List factors affecting correct battery selection.
3. Select the appropriate battery to meet starting system needs. (Assignment Sheet 1)
4. Inspect, service, and replace a battery. (Job Sheet 1)
5. Perform a battery load test. (Job Sheet 2)
6. Slow and fast charge a battery. (Job Sheet 3)
7. Label the parts of a starting system indicated on an illustration.
8. Match the names of the parts of a starting system to descriptions of their functions.
9. Arrange the steps of starting system operation in order.
10. List the components tested by starting/charging system tests.
11. Match the names of starting/charging system tests with descriptions of the conditions evaluated by the tests.
12. Describe how starting/charging test equipment is hooked up to the vehicle.
13. Perform a starter current draw test. (Job Sheet 4)
14. Perform voltage drop tests. (Job Sheet 5)
15. Inspect, test, and repair or replace components and wires in the starter control circuit. (Job Sheet 6)
16. Diagnose starting system problems. (Assignment Sheet 2)
17. State the purpose of a charging system.
18. Label the parts of a charging system indicated on an illustration.
19. State the purpose of an alternator.
20. Inspect, adjust, and replace alternator drive belts, pulleys, and fans. (Job Sheet 7)
21. Inspect, repair, and replace charging circuit connectors and wires. (Job Sheet 8)
22. Diagnose charging system problems that cause an undercharge, overcharge, or a no-charge condition. (Assignment Sheet 3)

INFORMATION SHEET

SERVICING STARTING AND CHARGING SYSTEMS

2

OBJECTIVE 1

List safety rules for working with automobile batteries.

- **Always wear safety glasses, rubber gloves, and a rubber apron when working with batteries.**

  ☑ **NOTE:** When working with batteries, you always run the risk of coming into contact with the acid inside the battery cells. This acid, called *electrolyte*, is strong enough to destroy clothing and burn eyes and skin. Always protect yourself from possible electrolyte burns by wearing the protective equipment listed above.

- **Always keep a mixture of baking soda and water nearby when working with batteries.**

  ☑ **NOTE:** If electrolyte is accidentally spilled or splashed on your clothing or skin, wash the exposed clothing or skin with the baking soda and water solution and then rinse with clean water. If electrolyte is spilled or splashed on a vehicle's metal surfaces, wash the exposed surface with the solution and then rinse with cold water.

- **Do not smoke near a battery on charge or near recently charged batteries.**

  ☑ **NOTE:** When batteries are being charged, a gas forms in the battery's cells. Some of this gas escapes through the battery's vent holes, forming an explosive atmosphere around the battery that can remain for several hours after the charge. Flames can ignite the gas around the battery, causing an explosion.

- **Do not break live circuits at the battery.**

  ☑ **NOTE:** A spark usually occurs at the point where the circuit is broken. This spark can also ignite the gas that forms around a battery.

OBJECTIVE 2

Required Activities/
Resources
– Explanation

List factors affecting correct battery selection.

Listen as your instructor explains the factors which affect the correct selection of a battery.

- **Manufacturer's recommended battery size**
- **Battery Council International (BCI) rating**

  NOTE: The BCI rating assigns a battery group number regarding the reserve capacity power and cold cranking amperes (CCA) needed for a replacement battery. A 12-volt battery generally requires one ampere per cubic inch of engine size, so a 350 cubic inch engine would require a battery with at least 350 cold cranking amperes. whether or not the vehicle has air conditioning

- **Temperature of the surroundings in which the vehicle will operate**

  EXAMPLE: cold climate, hot climate, etc.

- **Electrical options added to the vehicle before and after market**
- **Whether or not the vehicle has air conditioning**

OBJECTIVE 3

Complete Assignment Sheet 1.

OBJECTIVE 4

Complete Job Sheet 1.

OBJECTIVE 5

Complete Job Sheet 2.

OBJECTIVE 6

Complete Job Sheet 3.

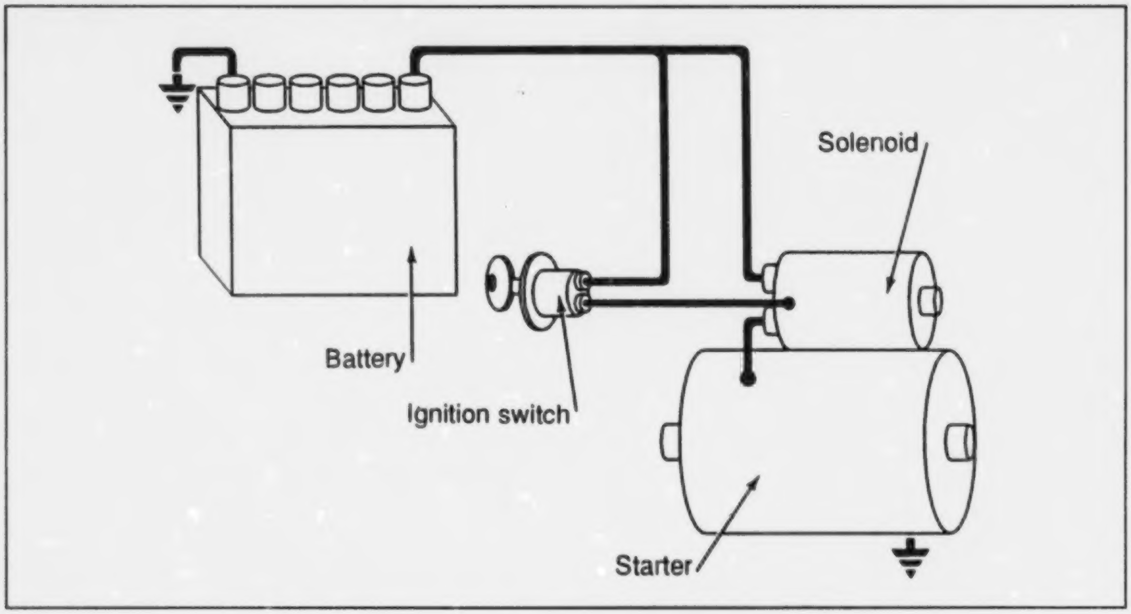
OBJECTIVE 7

Required Activities/
Resources
– Transparency Master 1

Label the parts of a starting system indicated on an illustration.

Look at transparency 1 illustrating the parts of a starting system as your instructor explains how the parts work together in starting system operation.

FIGURE 1



OBJECTIVE 8

Required Activities/ Resources
- Starting system parts

Match the names of the parts of a starting system to descriptions of their functions.

Look at the parts of a starting system as your instructor explains the function of each part.

- **battery** — provides electrical current for the starting, ignition, lighting, and other electrical components
- **ignition switch** — opens and closes the circuit that transfers current from the battery to the solenoid
- **solenoid** — switches on and off the high voltage current which cranks the starter
- **starter** — spins the flywheel to start the engine

OBJECTIVE 9

Arrange the steps of starting system operation in order.

1. As the ignition key is turned, the solenoid switch closes, allowing high current to flow from the battery cables through the solenoid to the starter.
2. The starter's drive pinion gear begins to turn, moving the ring gear around the engine flywheel.

3. As the ring gear turns, it spins the crankshaft fast enough for the air-fuel mixture to enter the cylinders and start the engine.

OBJECTIVE 10

List the components tested by starting/charging system tests.

- alternator
- battery
- starter
- wiring and switches

OBJECTIVE 11

Required Activities/
Resources
– Explanation

Match the names of starting/charging system tests with descriptions of the conditions evaluated by the tests.

Listen as your instructor explains the conditions which are evaluated by starting/charging system tests.

- **alternator output test** — measures the maximum current the alternator can produce at a specified voltage

- **battery high rate discharge test** — measures the lowest point to which the battery voltage drops while the battery is discharging at a high rate

  NOTE: A battery high rate discharge test is commonly called a battery load test. A decal on the top of the battery usually gives the cold-cranking amps (CCA) used to determine the load to be placed on the battery.

- **circuit voltage drop test** — evaluates resistance across a cable, component, or connection during current flow

- **starter draw test** — measures the current flow to the starting motor during engine cranking

- **state-of-charge test** — checks the voltage level of the battery charge in batteries that do not have a charge indicator on the top

  NOTE: The minimum battery charge for load testing is 2.1 volts per cell or 12.6 volts. If the battery is not charged to 12.6 volts, it should be charged before load testing.

OBJECTIVE 12 **Describe how starting/charging test equipment is hooked up to the vehicle.**

Required Activities/
Resources
- Hydrometer
- Inductive amp gauge
- Multimeter
- Vat 40

☞ Watch as your instructor demonstrates how to hook up the starting/charging test equipment.

- **charging system/load tester** — The leads are connected to the positive and negative battery terminals; use the equipment operating manual for directions on connecting other leads.

  ☑ **NOTE:** VAT 40 or equivalent. This is the method for hooking it up for charging; there is another way for hooking it up for starting system testing.

- **hydrometer** — The rubber tube or stick end of the hydrometer is placed into the electrolyte fluid inside the battery.

- **inductive amp gauge** — The ammeter pickup is clamped around the positive battery cable.

- **multimeter** —

  - **voltmeter function** — The multimeter probes are placed in the test circuit on either side of the load being tested.

  - **ammeter function** — The multimeter probes are placed in the test circuit between the power source and the load.

    ☑ **NOTE:** If a multimeter in the ammeter function is connected as you would connect it if it were in the voltmeter function, the multimeter may be destroyed.

  - **ohmmeter function** — After the wire or component being tested has been disconnected from a source of voltage, the multimeter probes are placed on either side of the wire or component being tested.

OBJECTIVE 13 **Complete Job Sheet 4.**

OBJECTIVE 14 **Complete Job Sheet 5.**

OBJECTIVE 15 **Complete Job Sheet 6.**

OBJECTIVE 16 **Complete Assignment Sheet 2.**

OBJECTIVE 17

State the purpose of a charging system.

The purpose of a charging system is to restore the battery's electrical charge.

NOTE: When the vehicle is in use, the battery is constantly being drained of electricity by all the systems which use electricity. The charging system replaces this electricity.

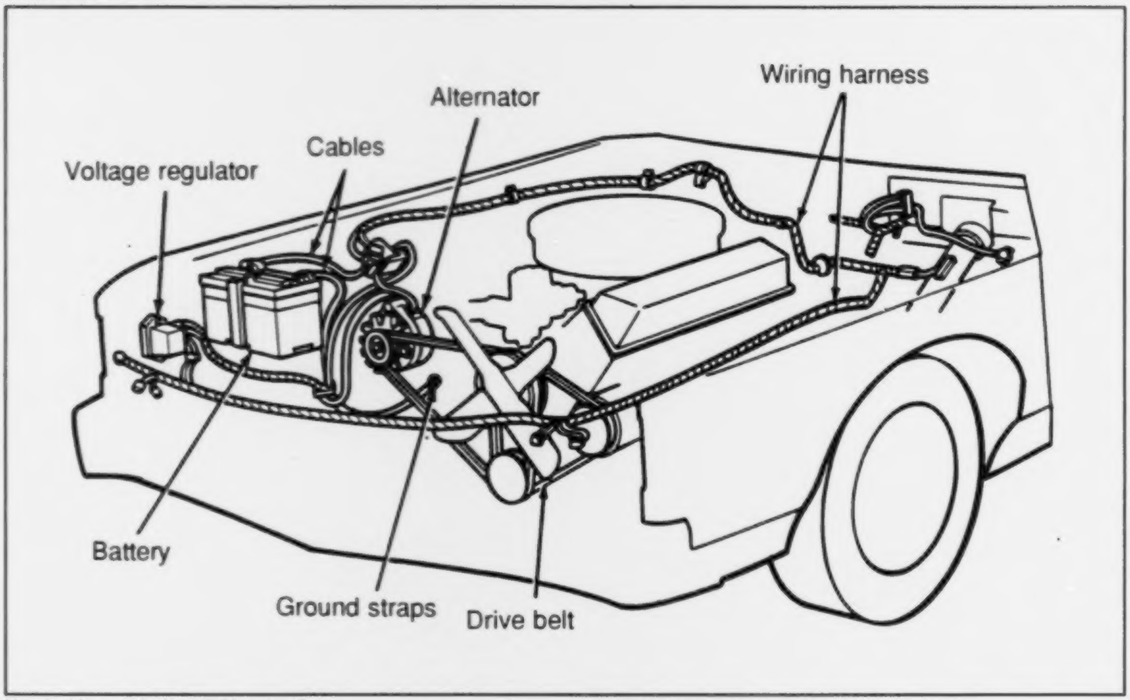
OBJECTIVE 18

Required Activities/
Resources
– Transparency Master 2

Label the parts of a charging system indicated on an illustration.

Look at transparency 2 illustrating the parts of a charging system as your instructor describes the operation of the charging system.

FIGURE 2



Used with permission of Chrysler Corp.

NOTE: In addition to the parts shown above, the charging system also includes a status light or gauge on the dashboard which shows the condition of charge.

OBJECTIVE 19 **State the purpose of an alternator.**

Required Activities/
Resources
– Explanation

Listen as your instructor explains how an alternator operates.

The purpose of an alternator is to convert mechanical energy from the operation of the engine into the electrical energy required to restore the electrical charge of the battery.

OBJECTIVE 20 **Complete Job Sheet 7.**

OBJECTIVE 21 **Complete Job Sheet 8.**

OBJECTIVE 22 **Complete Assignment Sheet 3.**

ASSIGNMENT SHEET 1

SERVICING STARTING AND CHARGING SYSTEMS

2

Name ______________________________ Score __________

OBJECTIVE 3

Select the appropriate battery to meet starting system needs.

Required Activities/Resources
- Handouts 1 and 2
- Information Sheet, obj. 2

Listen as your instructor explains the material in Handouts 1 and 2 and Information Sheet objective 2.

INTRODUCTION

Vehicle service manuals will list the battery capacity and BCI group number specifications for replacement batteries. A replacement battery must be the same physical size and have a voltage capacity equal to or higher than the original battery. Choosing a battery smaller than suggested capacity will cause starting problems, shorten battery life, and overwork the charging system.

EQUIPMENT AND SUPPLIES

- Handout 1, Choosing a New Battery
- Handout 2, Estimated Battery Drain of Vehicle Optional Equipment
- Information Sheet, objective 2

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Math Application
- Use English and metric measures

Use Handouts 1 and 2 and Information Sheet, objective 2 to help you with this Assignment Sheet. Read each of the following questions carefully, then select the answer for each that is correct. Write the correct letter in the blank.

_____ 1. Technician A says that a vehicle operating in a warm climate needs a larger battery than one operating in a cold climate. Technician B says that vehicles operating in a cold climate need a larger battery. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

2. Can you harm a vehicle by using too large a battery?

Yes No (circle one)

General Science
- Investigate/apply technology

Cognitive Activities
- Draw conclusions
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure

3. Your old battery, rated at 400 CCA, needs to be replaced. What is the preferred rating you should select for your new battery?

____

____ 4. Which of the following uses more electricity from the battery?

A. Digital clock
B. Engine computer
C. Air conditioner or heater set on low
D. Rear windshield defogger

____ 5. Which of the following problems is a battery that is too small (too few CCA) most likely to cause?

A. Inability to hold a charge
B. Problems starting the vehicle
C. Operating problems in the electrical equipment
D. More frequent routine battery maintenance

____ 6. Technician A says the general rule for battery selection is at least 350 CCA for engines smaller than 300 CID (5 liter), and at least 450 CCA for larger engines. Technician B says there is no rule of thumb. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

7. Name at least three aftermarket products that, added to the vehicle, will cause an increase in battery needs.

A. ____

B. ____

C. ____

____ 8. The terminals on a customer's present battery are located on the top of the battery. He has found a battery on sale that is just the right size for his vehicle, but the battery terminals are on the side. Technician A says he should only buy a battery with the terminals on top. Technician B says the sale battery would do just as well. Who is correct?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

9. Do larger engines need a larger battery just to start than smaller engines do?

Yes No (circle one)

10. Regardless of other considerations, you should always select a battery at least the size the manufacturer recommends.

True False (circle one)

ASSIGNMENT SHEET 2

SERVICING STARTING AND CHARGING SYSTEMS

2

Name ______________________ Score __________

OBJECTIVE 16

Diagnose starting system problems.

Required Activities/
Resources
– Handout 3

Listen as your instructor explains the material in Handout 3.

INTRODUCTION

The cause of an engine's starting problems may be in the parts or circuit of the starting system. Diagnosing these problems will involve inspection of the system parts for probable causes, testing, and repairing or replacing as needed.

EQUIPMENT AND SUPPLIES

- Handout 3, Starting System Diagnosis Chart

INSTRUCTIONS

Use Handout 3 to help you with this Assignment Sheet. Read each of the following questions carefully, then select the answer for each that is correct. Write the correct letter in the blank.

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

General Science
- Investigate/apply technology

Cognitive Activities
- Draw conclusions
- Transfer knowledge/training to new situations

_____ 1. A customer brings in a vehicle complaining of hearing a siren-like sound after starting. Which of the following could cause this problem?

A. High resistance in the starter
B. A defective overrunning clutch
C. Loose or corroded battery terminals
D. Discharged battery

_____ 2. You have just determined that a vehicle has a wiring problem inside the solenoid. How would you correct the problem?

A. Rewire the solenoid.
B. Replace the solenoid.
C. Clean the wiring in the solenoid.
D. Repair the wiring in the solenoid.

Job Acquisition/Development
- Master specific job task/procedure

____ 3. Which of the following is the most common reason for a vehicle to not crank and the lights to not work?

A. A discharged battery
B. A poor battery connection
C. An open circuit in the battery
D. Battery cables that are too small

____ 4. What could be a reason an engine cranks slowly but will not start?

A. The outside temperature is low.
B. The outside temperature is high.
C. The battery cables are too large.
D. The battery is too large for the vehicle.

____ 5. In following up on a customer complaint, you find a short in the starter. Which of the following is a solution to this problem?

A. Replace or repair the battery.
B. Replace or repair the starter.
C. Replace or repair the solenoid.
D. Replace or repair the starter armature.

____ 6. What is the first thing you would check on a vehicle that does not crank but the lights stay bright?

A. A high resistance in the circuit
B. A high resistance at the battery connection
C. An open circuit in the safety switch
D. An open circuit in the starter

____ 7. Which of the following could happen if the starter and flywheel are out of alignment?

A. The solenoid clicks, chatters.
B. The starter turns, but the engine does not.
C. The lights stay bright; the vehicle doesn't crank.
D. The vehicle doesn't crank, and the lights are out.

____ 8. You have just determined that a vehicle has a high resistance at the battery connection. What would you do to correct the problem?

A. Test the battery.
B. Clean and tighten the battery terminal connections.
C. Allow the battery time to warm.
D. Replace the battery.

_____ 9. You have checked for a defective overrunning clutch and a sticking solenoid plunger. They are both okay, but the engine still whines after starting. What would you do next?

A. Replace the clutch.
B. Replace the solenoid plunger.
C. Check and repair safety switch in starter.
D. Check for a weak return spring.

_____ 10. An engine cranks very slowly, then will not start. You realize the battery is discharged. What is the first thing you would do to correct the problem?

A. Test the alternator.
B. Test the battery.
C. Replace the battery.
D. Charge the battery.

ASSIGNMENT SHEET 3

SERVICING STARTING AND CHARGING SYSTEMS

Name ______________________ Score __________

OBJECTIVE 22

Diagnose charging system problems that cause an undercharge, overcharge, or a no-charge condition.

Required Activities/ Resources
– Handout 4

Listen as your instructor explains the material in Handout 4.

INTRODUCTION

The regulation and supply of voltage from the charging system are essential for engine performance. Low voltage can cause a malfunctioning lighting and electrical system. High charging voltage can damage expensive electronic parts.

EQUIPMENT AND SUPPLIES

- Handout 4, Charging System Diagnosis Chart

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

General Science
- Investigate/apply technology

Cognitive Activities
- Transfer knowledge/training to new situations

Use Handout 4 to help you with this Assignment Sheet. Read each of the following questions carefully, then select the answer for each that is correct. Write the correct letter in the blank.

_____ 1. What is the most likely cause of an overcharged system?

A. High resistance in the alternator
B. Faulty regulator
C. Defective battery
D. Low resistance in the alternator

_____ 2. You have checked an undercharging battery for loose wiring connections and high resistance in the alternator circuit and found the alternator and wiring to be in operating order. What do you now suspect is the problem?

A. A defective regulator
B. A defective battery
C. A defective drive belt
D. A defective starter motor

Job Acquisition/ Development
- Master specific job task/procedure

____ 3. A vehicle with low or no-charge voltage is found to have dirty battery cables. What would be the solution to this problem?

A. Replace the battery.
B. Replace the wiring.
C. Clean the alternator.
D. Clean the battery cables.

____ 4. You have just determined that a vehicle has a faulty ground at the regulator. How would you correct the problem?

A. Replace the regulator.
B. Repair the regulator ground.
C. Replace the battery.
D. Repair the battery cables.

____ 5. What could be a reason for faulty operation of a vehicle's electrical options?

A. High resistance in the circuit
B. Defective drive belt
C. Incorrect battery
D. Defective solenoid

____ 6. In following up on a customer's complaint, you find that the vehicle has a battery too small to handle the electrical needs of the vehicle. Which of the following is the solution to the problem?

A. Clean the battery and cables.
B. Charge the battery.
C. Use with larger battery cables.
D. Replace with a battery of the correct capacity.

____ 7. How would you correct the problem of a faulty regulator?

A. Repair the alternator.
B. Inspect and repair circuit wiring.
C. Adjust the drive belt.
D. Adjust or replace the regulator.

JOB SHEET 1

SERVICING STARTING AND CHARGING SYSTEMS

2

Name ______________________________

OBJECTIVE 4

Inspect, service, and replace a battery.

INTRODUCTION

Automotive batteries must be inspected and serviced to maintain long battery life, but a damaged or worn out battery must be replaced. Preventive maintenance includes a visual inspection, cleaning, reconnection, and, if necessary, the replacement of the battery cables.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Full face shield
- Masking tape
- Rubber gloves
- Rubber apron
- Box end wrench or special battery pliers
- Locking pliers or channel-lock pliers
- Battery clamp puller
- Wire brush
- Terminal cleaning tool
- Scrub brush
- One quart baking soda and water solution (4 tablespoons of baking soda to 4 cups of water)
- New battery cables
- Appropriate replacement battery
- Anticorrosion compound
- Shop towel
- Distilled water
- Flashlight
- Clean water
- Battery carrier or lifting strap
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

General Science
- Investigate/apply technology

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Check the electrolyte level in a conventional battery Yes No

1. Remove each filler cap. ____ ____
2. Check the electrolyte level by looking into each vent, using a flashlight if necessary. ____ ____
3. If the tops of the battery plates can be seen above the level of electrolyte, slowly add distilled water until the plates are fully covered. ____ ____
4. Replace the filler caps. ____ ____
5. Check to be sure the vent holes in the filler caps are open. ____ ____

⚠ **WARNING:** CLOGGED VENT HOLES can cause the battery to explode. MAKE SURE THE VENT HOLES IN THE VENT CAP ARE KEPT OPEN.

PROCEDURE

Job Acquisition/ Development
- Master specific job task/procedure

Check the electrolyte level in a maintenance-free battery

1. Observe the color of the built in hydrometer. ____ ____

   ☑ **NOTE:** If the hydrometer shows green or red, the electrolyte level is sufficient.

2. Replace the battery if the hydrometer shows clear or light yellow. ____ ____

   ☑ **NOTE:** This color means the electrolyte level is low and, since the battery is maintenance-free, electrolyte cannot be added.

PROCEDURE

Job Acquisition/ Development
- Master specific job task/procedure

Inspect and disconnect the battery Yes No

1. Examine the battery for:
   - signs of leakage (corrosion on the battery carrier, inner fender, or vehicle frame) ____ ____
   - cracked case ____ ____
   - missing vent plugs ____ ____
   - loose or missing cable clamps ____ ____

Yes No

2. Check the battery terminals and cable clamps for corrosion. ____ ____

☑ **NOTE:** Battery terminals, especially top-mounted terminal posts, tend to corrode. Corrosion builds up around the cable clamps and between the terminals and cable clamps.

3. Disconnect the negative terminal clamp. ____ ____

⚠ **NOTICE:** REMOVING THE POSITIVE TERMINAL FIRST may cause a spark. ALWAYS REMOVE THE NEGATIVE TERMINAL BEFORE YOU REMOVE THE POSITIVE TERMINAL.

---

4. On nut and bolt type clamps, use a box end wrench or special battery pliers to loosen the clamp nut about ⅜ inch; if the clamp is heavily corroded, use a clamp puller to remove the clamp from the terminal. ____ ____

☑ **NOTE:** On spring ring type clamps, squeeze the end of the rings apart with locking or channel-lock pliers.

5. Disconnect the positive terminal cable clamp following the procedures in step 4. ____ ____

6. Examine both battery cables, starting at the battery and working to the other end. Look for:
   - loose clamps or connections ____ ____
   - cut, scratched, or damaged insulation ____ ____
   - tight kinks or bends, which might indicate damaged conductors ____ ____

7. If you find any of these problems, or other kinds of damage, the cable must be replaced. ____ ____

☑ **NOTE:** You should not use add-on cable ends, tape the insulation, or attempt to straighten out tightly kinked battery cables. New cables must be at least 2 or 0 gauge wire to carry the large current needed by the starter. Even if the original battery cables were smaller, use 2 or 0 gauge replacement battery cables. Be sure to use cables of the same length or shorter length then the original cables. Always replace both battery cables at the same time.

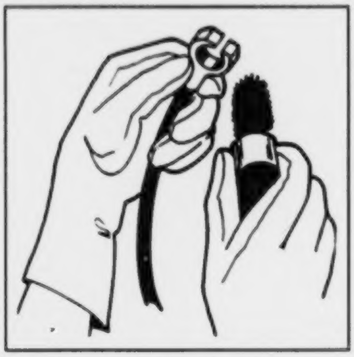
PROCEDURE

Job Acquisition/Development
- Master specific job task/procedure

Clean the battery

	Yes	No
1. Use a wire brush to clean the cable clamps until the metal looks shiny and bright. (Figure 1)	___	___

FIGURE 1



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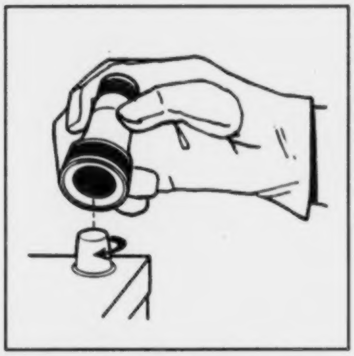
	Yes	No
2. Use a terminal post cleaning tool or a wire brush to clean the terminal posts until the metal looks shiny and bright. (Figure 2)	___	___

⚠ **NOTICE:** PARTICLES OF CORROSION WHICH FALL ON A VEHICLE OR ITS PARTS CAN RUIN THE VEHICLE'S PAINT AND CORRODE OTHER VEHICLE PARTS.

FIGURE 2



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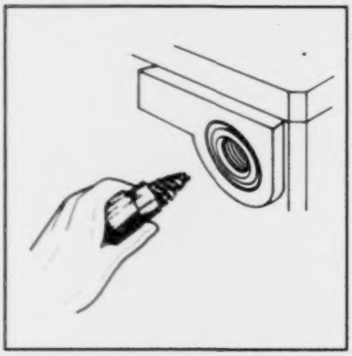
Yes No

3. On side-mounted terminals, use a wire brush to clean both sides of the terminal clamps. (Figure 3) ____ ____

FIGURE 3



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4. Use a wire brush to clean the terminal contact areas. ____ ____

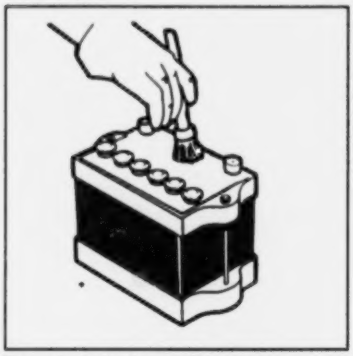
☑ **NOTE:** Sometimes the battery is so corroded that it must be removed from the vehicle in order to be cleaned properly. If this is necessary, loosen the battery hold-downs and remove the battery from the vehicle before proceeding.

5. Brush baking soda and water solution on the battery case, terminals, and cable clamp. (Figure 4) ____ ____

⚠ **CAUTION:** IF BAKING SODA AND WATER SOLUTION is allowed to clog the battery vent holes, the resulting chemical reaction can cause pressure buildup and the possible spewing of electrolyte. DO NOT ALLOW THE BAKING SODA SOLUTION TO GET INTO THE VENT HOLES.

FIGURE 4

Yes No



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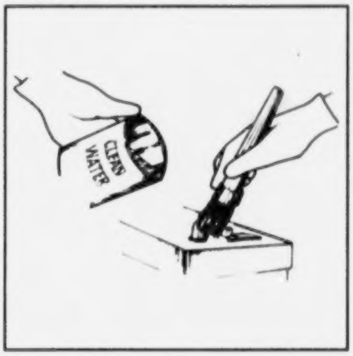
6. When the baking soda solution stops foaming, wash the residue away with clean water and brush with a scrub brush to remove stubborn residue. (Figure 5) ____ ____

7. Dry the battery, terminals, and cables with a clean shop towel. ____ ____

⚠ **WARNING:** IF AN AIR HOSE IS USED to dry a battery, the air can pull the electrolyte out through the vent caps, spraying acid mixture over your body and the vehicle. DO NOT USE AN AIR HOSE TO DRY A BATTERY.

FIGURE 5



PROCEDURE

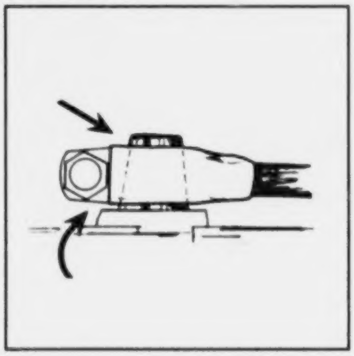
Job Acquisition/ Development
- Master specific job task/procedure

Replace the battery cables

1. Disconnect the old negative cable from the ground on the body. ____ ____

	Yes	No
2. Disconnect the old positive cable from the electrical system.	____	____
3. Connect a new positive cable to the electrical system.	____	____
4. Connect a new negative cable to the ground on the body.	____	____
5. If the battery has been removed from the vehicle for cleaning, reinstall it and tighten the hold-downs, being careful not to overtighten.	____	____
6. Reconnect the positive cable to the positive terminal, making sure the cable clamp is tight and in the correct position. (Figure 6)	____	____

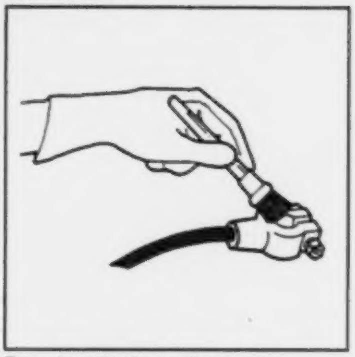
FIGURE 6



⚠ **WARNING:** CONNECTING THE NEGATIVE TERMINAL FIRST will lead to severe shock. ALWAYS CONNECT THE POSITIVE TERMINAL BEFORE YOU CONNECT THE NEGATIVE TERMINAL.

	Yes	No
7. Reconnect the negative terminal cable, making sure the cable clamp is tight and in the correct position.	____	____
8. Spread or spray anticorrosion compound over the cable clamps and terminals. (Figure 7)	____	____

FIGURE 7



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PROCEDURE

Job Acquisition/Development

- Master specific job task/procedure

Replace the battery

1. If the battery cables are not marked, use a bit of masking tape to mark the positive and the negative cables before disconnecting them from the old battery. ____ ____
2. Disconnect the battery negative terminal clamp. ____ ____

   ☑ **NOTE:** If the clamps are the nut and bolt type, remove them with a box end wrench or special battery pliers. Loosen the clamp nut about 3/8 inch. If the clamps are the spring ring type, remove them by squeezing the end of the rings apart with locking or channel-lock pliers.

⚠ **WARNING:** REMOVING THE POSITIVE TERMINAL FIRST may cause a spark. ALWAYS REMOVE THE NEGATIVE TERMINAL BEFORE YOU REMOVE THE POSITIVE TERMINAL.

---

3. Disconnect the positive terminal clamp. ____ ____
4. Remove any battery hold down hardware. ____ ____
5. Remove the battery using a battery carrier or lifting strap. ____ ____
6. Install the replacement battery using a battery carrier or lifting strap. ____ ____
7. Tighten all hold down hardware securely. ____ ____

Yes No

8. Reconnect the positive cable to the positive terminal, making sure the connectors are even with, or slightly below, the tops of the posts. ____ ____

⚠ **WARNING:** CONNECTING THE NEGATIVE TERMINAL FIRST will lead to severe shock. ALWAYS CONNECT THE POSITIVE TERMINAL BEFORE YOU CONNECT THE NEGATIVE TERMINAL.

---

9. Reconnect the negative cable to the negative terminal, making sure the connectors are even with, or slightly below, the tops of the posts. ____ ____
10. Spread or spray anticorrosion compound over the cable clamps and terminals. ____ ____
11. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. ____ ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1

Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 2

SERVICING STARTING AND CHARGING SYSTEMS

2

Name ____

OBJECTIVE 5

Perform a battery load test.

INTRODUCTION

A load test (sometimes called a *capacity test*) is the most common and informative battery test used in starter system service. The test is useful because it measures the battery's ability to deliver energy while it is working under a load.

A load test can be performed with various types of test equipment, but the equipment most commonly used by automotive technicians is a volt-amp tester. The volt-amp tester combines an ammeter and a voltmeter with a resistance unit (*load*) that is adjusted with a load-control knob.

During use, the volt-amp tester leads are connected to the battery terminals, and the load-control knob is turned, adjusting the load placed on the battery until a specified current shows on the ammeter. The voltmeter is then read to obtain a measure of the battery's voltage after the load has been maintained for 15 seconds.

The following procedure provides safety guidelines and outlines the steps typically used in load-testing batteries. You must follow all general safety rules for dealing with batteries. Study the manufacturer's instructions before operating the tester used in your shop. Refer to the battery manufacturer's specifications or the automobile's service manual procedure to know how much load to place on the battery you will be testing and how to interpret the results of the battery test.

EQUIPMENT AND SUPPLIES

- Battery and battery manufacturer's specifications
- Appropriate service manual
- Volt-amp tester and manufacturer's operating instructions
- Rubber gloves
- Rubber apron
- Glass thermometer
- Post adapters (if the battery terminals are side-mounted)
- Pencil and paper
- Watch, clock, or timer
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Load test a conventional battery Yes No

1. If the battery is inside the vehicle, place fender covers over the fenders. ____ ____
2. Perform a visual inspection of the battery; clean the battery if necessary. (Job Sheet 1) ____ ____
3. If it is very cold, test the battery temperature by removing a battery filler cap and inserting a thermometer into the electrolyte in the battery cell. ____ ____
4. If the electrolyte temperature is less than 60 degrees F, allow the temperature to rise and remeasure the temperature periodically until the temperature reads at least 60 degrees. ____ ____
5. Leave the thermometer in the electrolyte and perform a battery state-of-charge test. (Job Sheet 3) ____ ____
6. Proceed with the load test only if the battery is within the range specified. ____ ____

   ☑ **NOTE:** Normally 1.200 specific gravity at 80 degrees F

7. If the battery is in the vehicle, disconnect the battery cables from the terminals. ____ ____

⚠ **WARNING:** REMOVING THE POSITIVE TERMINAL FIRST may cause a spark. ALWAYS REMOVE THE NEGATIVE TERMINAL BEFORE YOU REMOVE THE POSITIVE TERMINAL.

8. If you are testing a battery with side-mounted terminals, insert post adapters to provide a good connection for the volt-amp-tester leads. ____ ____

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Math Application
- Use English and metric measures

Data Analysis and Display
- Collect/record data

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

9. Follow the volt-amp tester manufacturer's instructions for preparing the tester for a load test and for connecting the tester leads to the battery terminal posts or adapters. ____ ____

⚠ **WARNING:** CONNECTING OR DISCONNECTING THE TESTER LEADS to the battery in any sequence other than the one recommended by the tester manufacturer can cause the battery to explode. FOLLOW MANUFACTURER INSTRUCTIONS IN CONNECTING AND DISCONNECTING THE TESTER LEADS.

---

10. Refer to the appropriate service manual or battery-manufacturer's specifications to determine the correct load to place on the battery being tested. ____ ____

☑ **NOTE:** Some manufacturers provide specific load rates for their batteries; other manufacturers recommend that the load equal three times the ampere-hour rating or one-half the cold-cranking rating.

11. Remove the surface charge from the battery by turning the load control knob until the specified load has been placed on the battery for 15 seconds; then immediately turn the knob back to the OFF position. ____ ____

⚠ **CAUTION:** APPLYING LOAD TO THE BATTERY for more than 15 seconds will overheat the test equipment. DO NOT APPLY LOAD TO THE BATTERY FOR MORE THAN 15 SECONDS.

---

12. Wait 15 seconds and then turn the load control knob until the specified load has been placed on the battery for 15 seconds. ____ ____

13. Quickly note the voltage indicated on the voltmeter, and immediately turn the control knob to the OFF position. ____ ____

14. Record the voltmeter reading. ____ ____

15. Record the electrolyte temperature. ____ ____

Yes No

16. Remove the thermometer from the battery. ____ ____

17. Follow the volt-amp tester manufacturer's instructions for disconnecting the tester from the battery. ____ ____

18. Interpret the load-test results by comparing voltage and temperature readings to service manual or battery manufacturer's specifications. ____ ____

☑ **NOTE:** Most specifications indicate that a battery is good when it maintains a voltage of at least 9.6 volts while the specified load is applied when the electrolyte temperature is at 70 degrees F or above. Use the specifications to determine the minimum voltage allowable for temperatures lower than 70 degrees.

19. If the voltage reading is below the minimum specified, recharge and retest, then replace the battery if required. ____ ____

20. If the voltage reading is the same as or more than the minimum specified, clean and charge the battery before returning it to service. ____ ____

PROCEDURE

Job Acquisition/ Development
- Master specific job task/procedure

Load test a maintenance-free battery

1. If the battery is inside the vehicle, place fender covers over the fenders. ____ ____

2. Perform a visual inspection of the battery; clean the battery if necessary. (Job Sheet 1) ____ ____

4. Estimate the battery's temperature by taking into consideration not only the temperature of the battery's environment in the hours just before testing, but how hot or cold the battery case feels to the touch. ____ ____

4. Record the estimated battery temperature. ____ ____

5. Test the battery state-of-charge by looking at the built-in hydrometer. (Job Sheet 1) ____ ____

	Yes	No
6. Record the state-of-charge test results.	____	____
7. If a red dot appears in the built-in hydrometer, charge the battery (Job Sheet 3) until a green dot is visible in the hydrometer.	____	____
8. If the hydrometer appears clear or light yellow, replace the battery.	____	____
9. Proceed with the load test only if a green dot is visible in the hydrometer.	____	____
10. Refer to the appropriate service manual or battery manufacturer's specifications to determine the correct load to be placed on the battery at the temperature estimated in step 7.	____	____
11. If the battery is in the vehicle, it may be necessary to disconnect the battery cables from the terminals.	____	____

⚠ **WARNING:** REMOVING THE POSITIVE TERMINAL FIRST can cause a spark. ALWAYS REMOVE THE NEGATIVE TERMINAL BEFORE YOU REMOVE THE POSITIVE TERMINAL.

	Yes	No
12. If you are testing a battery with side-mounted terminals, insert post adapters, if required, to provide a good connection for the volt-amp-tester leads.	____	____
13. Follow the volt-amp tester manufacturer's instructions for preparing the tester for a load test and for connecting the tester leads to the battery-terminal posts or adapters.	____	____

⚠ **WARNING:** CONNECTING OR DISCONNECTING THE TESTER LEADS to the battery in any sequence other than the one recommended by the tester manufacturer can cause the battery to explode. FOLLOW MANUFACTURER INSTRUCTIONS IN CONNECTING AND DISCONNECTING THE TESTER LEADS.

Yes No

14. Remove the surface charge from the battery by turning the load-control knob until the specified load has been placed on the battery for 15 seconds, then immediately turn the control knob back to the OFF position. ____ ____

⚠ **CAUTION:** APPLYING LOAD TO THE BATTERY for more than 15 seconds will overheat the test equipment. DO NOT APPLY LOAD TO THE BATTERY FOR MORE THAN 15 SECONDS.

---

15. Wait 15 seconds and turn the load-control knob until the specified load has been placed on the battery for 15 seconds. ____ ____

16. Quickly note the voltage indicated on the voltmeter, and then turn the control knob back to the OFF position. ____ ____

17. Record the voltmeter reading. ____ ____

18. Follow the manufacturer's instructions for disconnecting the tester from the battery. ____ ____

19. Interpret the load-test results by comparing the voltage and temperature readings to the service manual specifications or the battery manufacturer's specifications. ____ ____

☑ **NOTE:** Most specifications indicate that a battery is good when it maintains a voltage of at least 9.6 volts while the specified load is applied when the electrolyte temperature is at 70 degrees F or above. Use the specifications to determine the minimum voltage allowable for temperatures lower than 70 degrees.

20. If the readings are below the minimum specified, recharge and retest, then replace the battery if required. ____ ____

21. If the readings are the same as or exceed the minimum specified, clean and charge the battery (Job Sheet 3) before returning it to service. ____ ____

22. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. ____ ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 3

SERVICING STARTING AND CHARGING SYSTEMS

2

Name ____________________

OBJECTIVE 6 **Slow and fast charge a battery.**

INTRODUCTION

The two procedures for battery charging are the fast charge and slow charge. Fast chargers can charge batteries at a faster rate, usually in about one hour at 40 amperes for a 12-volt battery or 70 amperes for a 6-volt battery. A battery must be in good condition to accept a fast charge. You should not fast charge a battery that shows evidence of sulfation build-up or separator damage. Sulfation can lead to excessive gassing, boiling, and heat build-up.

Slow-charging a battery is the safest and most effective way to charge a battery and is the recommended method used in battery service. To slow-charge a battery, you must apply a charge figured in ampere-hours–the charge rate in amperes for a period of time in hours. For example, a 10-ampere charge rate for seven hours would be a 70-ampere-hour (AH) charge.

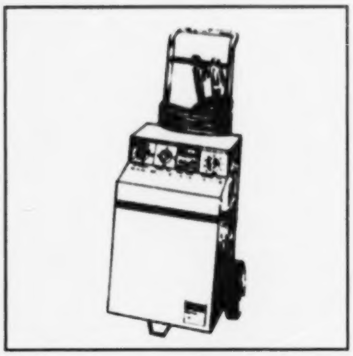
For most batteries, the battery charger (Figure 1) used in this procedure is typically set at an output of 5 amperes and is set for a time sufficient to bring the specific gravity of the electrolyte to its highest reading. However, the exact ampere-hour setting to use for a particular battery is difficult to determine because the following factors affect charging rates and times:

- The battery's size or electrical capacity in ampere-hours

  ☑ **NOTE:** A completely discharged 70-AH battery requires almost twice the recharging time and rate as a completely discharged 40-AH battery.

- The temperature of the battery's electrolyte

FIGURE 1



☑ **NOTE:** It takes about two hours longer to charge a battery with an electrolyte temperature of 0 degrees F than one of 80 degrees F.

- The battery's state-of-charge

☑ **NOTE:** A completely discharged battery requires twice as much charge as a battery that is half discharged.

- The battery's age and condition

☑ **NOTE:** A battery that has seen much service will require a higher rate of charge for a longer time than will a relatively new battery.

- The battery type

☑ **NOTE:** Maintenance-free batteries usually require a longer, more rapid rate of charge than a conventional battery. Many chargers will have a switch to allow you to adjust to the type of battery being charged.

EQUIPMENT AND SUPPLIES

- Battery and manufacturer's specifications
- Battery charger and manufacturer's operating instructions
- Appropriate service manual
- Rubber gloves
- Rubber apron
- Damp cloths or paper towels
- Post adapters (if the battery terminals are side-mounted)
- Thermometer
- Flashlight or shop light
- Pencil and paper
- Clock, watch, or timer
- Appropriate replacement battery
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Slow-charge a conventional battery Yes No

1. Check the battery temperature by removing the battery filler caps and looking down into the filler holes to determine the condition of the electrolyte; use a flashlight beam if necessary. ___ ___

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Math Application
- Use English and metric measures

Data Analysis and Display
- Collect/record data

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

	Yes	No
2. If the electrolyte appears to be frozen or if ice crystals are visible in the electrolyte, allow the battery to thaw fully before continuing.	____	____
3. Cover the battery filler holes with a damp cloth or damp paper towel.	____	____

☑ **NOTE:** Covering the filler holes with a cloth or paper towel will prevent the electrolyte from spewing from the filler holes during the charging procedure.

	Yes	No
4. Refer to the appropriate service manual or battery manufacturer's specifications to determine the charge rate and time recommended for the battery.	____	____
5. Record the charge rate and time.	____	____
6. If the battery is in the vehicle, it may be necessary to disconnect the battery cables from the terminals.	____	____
7. If you are charging a battery which has side-mounted terminals, insert post adapters to provide a good connection for the charger if required.	____	____

⚠ **WARNING:** REMOVING THE POSITIVE TERMINAL FIRST can cause a spark. ALWAYS REMOVE THE NEGATIVE TERMINAL BEFORE YOU REMOVE THE POSITIVE TERMINAL.

	Yes	No
8. Follow the charger manufacturers's instructions for preparing the charger for charge and for connecting the charger leads to the battery terminal posts or adapters.	____	____
9. Turn on the charger and adjust the charging rate and time to the settings suggested by the service manual or the charger equipment manual.	____	____
10. Charge the battery for 15 minutes.	____	____
11. Check the battery filler holes periodically for possible spewing of electrolyte. If the electrolyte is spewing, reduce the charge rate until the spewing stops.	____	____

Yes No

12. After the battery has charged for 15 minutes, insert the thermometer into the battery cell and take an electrolyte temperature reading. ____ ____

☑ **NOTE:** It is not necessary to stop the charging procedure to do this.

13. If the electrolyte temperature exceeds 125 degrees F, and/or electrolyte spewing has occurred, reduce the charging rate and continue to recheck every 15 minutes until the electrolyte temperature is under 125 degrees F and there is no spewing of electrolyte. ____ ____

14. After the allotted charge time has passed, check the battery filler holes. The battery should be bubbling freely. ____ ____

15. Follow the charger manufacturer's instructions for disconnecting the charger from the battery. ____ ____

16. Load test the battery (Job Sheet 2) and return it to service if it passes the load test. ____ ____

17. Clean your work area and return the equipment and supplies to proper storage or proceed to the next procedure or Job Sheet as directed by your instructor. ____ ____

PROCEDURE

Job Acquisition/ Development

- Master specific job task/procedure

Charge a maintenance-free battery

1. If the electrolyte appears to be frozen or if ice crystals are visible in the electrolyte, allow the battery to thaw fully before continuing. ____ ____

2. If a green dot shows in the hydrometer, charging is not necessary. Load test the battery (Job Sheet 2) and return it to service. ____ ____

3. If a black dot appears in the hydrometer, do not proceed with the slow-charging procedure; replace the battery. ____ ____

4. Proceed with slow-charge only if a red dot or clear yellowish fluid appears in the hydrometer. ____ ____

5. Refer to the appropriate service manual or battery manufacturer's specifications to determine the charge rate and time for the battery. ____ ____

Yes No

6. Record the charge rate and time. ____ ____

7. If the battery is in the vehicle, it may be necessary to disconnect the battery cables from the terminals. ____ ____

⚠ **WARNING:** REMOVING THE POSITIVE TERMINAL FIRST may cause a spark. ALWAYS REMOVE THE NEGATIVE TERMINAL BEFORE YOU REMOVE THE POSITIVE TERMINAL.

---

8. If you are charging a battery with side-mounted terminals, insert post adapters to provide a good connection for the charger if required. ____ ____

9. Follow the charger manufacturer's instructions for preparing the charger for charge and for connecting the charger leads to the battery terminal posts or adapters. ____ ____

10. Turn on the charger and adjust the charging rate and time. ____ ____

11. Charge the battery for the length of time recommended. ____ ____

12. If the battery is outside the vehicle, shake or tilt the battery at hourly intervals during charging to mix the electrolyte and remove the bubbles from around the hydrometer. ____ ____

    ☑ **NOTE:** These bubbles can sometimes cause the ball to stick, making an accurate state-of-charge evaluation impossible.

13. At the end of the time interval, check the battery for charge. ____ ____

    ☑ **NOTE:** The battery is sufficiently charged when a green dot is visible in the sight glass in the hydrometer.

14. If the green dot does not appear after the allotted charging time, the battery must be replaced. ____ ____

	Yes	No
15. Follow the charger manufacturer's instructions for disconnecting the charger from the battery.	____	____
16. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 4 — SERVICING STARTING AND CHARGING SYSTEMS — 2

Name ____

OBJECTIVE 13 **Perform a starter current draw test.**

INTRODUCTION

If you have determined that there is a problem in the starter, you must test the starter. Do not do this procedure if you have not already determined that the starting problem is not in the battery or the electrical system. If the starter is defective, it is frequently replaced rather than serviced.

EQUIPMENT AND SUPPLIES

- Vehicle with a negative ground starter system
- Appropriate service manual
- Feeler gauge
- Battery
- One set heavy duty jumper cables
- Wire feeler gauge
- RPM indicator
- Solenoid jumper cable
- Charging system/load tester
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Interpret graphics and symbols

	Yes	No
1. Disconnect the negative battery cable to prevent an accidental short circuit.	____	____
2. Disconnect the connections to the starter and the solenoid.	____	____
3. Remove the starter mounting bolts.	____	____
4. Lift the starter out of the engine housing and place it on a workbench.	____	____

Math Application
- Use English and metric measures

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

5. Notice any shims mounted under the starter and set them aside so you can replace them when you reinstall the starter. ____ ____

6. Inspect the starter motor for loose bolts, bad electrical connections, cracks, or other irregularities. ____ ____

7. Attempt to turn the pinion gear by hand. ____ ____

   ☑ **NOTE:** It should turn in one direction without binding but should not turn in the other direction.

8. If the pinion gear does not turn (in either direction) without binding, it is bent, or the bearings are frozen, and the pinion gear must be replaced. ____ ____

9. If the armature turns freely in both directions, the over-running clutch is defective, and the starter must be replaced. ____ ____

10. If the armature turns in one direction but not the other, set up the test circuit as shown in the next procedure. ____ ____

11. Connect the positive jumper cable from a fully charged battery to the starter terminal and place the negative jumper cable nearby but don't connect it yet. ____ ____

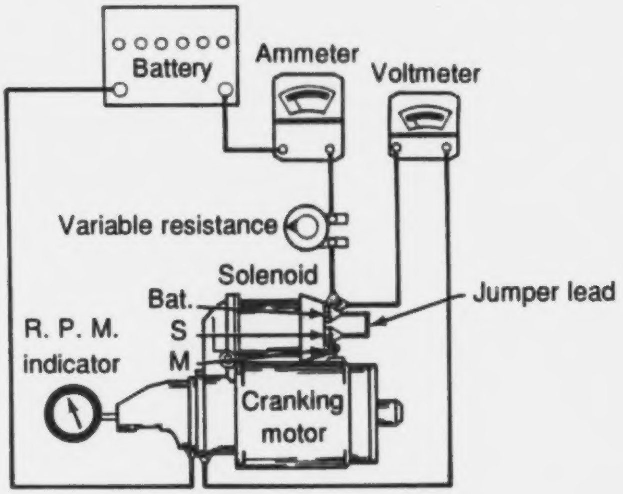
12. Connect a charging system/load tester to the starting motor terminal and the battery. ____ ____

    ☑ **NOTE:** The volt amp meter should be able to read several hundred amperes so it won't be damaged if the starter armature does not turn.

13. Connect the positive lead to the starter terminal and ground the negative lead to the starter frame at a place free of dirt, grease, or paint. ____ ____

    ☑ **NOTE:** The solenoid is normally included in the test circuit by inserting a jumper cable between the battery terminal (Bat) of the solenoid and the terminal for the ignition switch (S). (Figure 1) This activates the solenoid, holds the drive pinion in forward position, and starts the starter motor.

FIGURE 1


Battery
Ammeter
Voltmeter
Variable resistance
Solenoid
Bat.
S
M
Jumper lead
R. P. M. indicator
Cranking motor

Yes No

14. Before you close the test circuit, make sure the rheostat on the volt amp meter is set to maximum resistance so no current will be flowing through the circuit.

15. Clamp the negative jumper cable to the starter frame to close the circuit.

16. Decrease resistance on the rheostat until the voltmeter reads as specified by the starter manufacturer.

☑ **NOTE:** This reading is usually 5.5 volts on a 6-volt system and 10.6 volts on a 12-volt system.

17. With the starter motor running at maximum speed, place an rpm indicator against the drive end of the armature and read the speed.

18. Read the volt amp meter.

☑ **NOTE:** The current and speed under no load should be 5.5 volts and 60 amps at 2600 rpm for 6-volt systems. For 12-volt systems, it should be 11 volts and 65-100 amps at 3600-5100 rpm.

	Yes	No
19. If the readings fall outside the proper range, repair or replace the starter.	____	____
20. Remove the volt amp meter.	____	____
21. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

- **4** **Skilled** – Can perform job with no additional training.
- **3** **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
- **2** **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
- **1** **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS ______________________________

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____

JOB SHEET 5 — SERVICING STARTING AND CHARGING SYSTEMS — 2

Name ______________________________

OBJECTIVE 14

Perform voltage drop tests.

INTRODUCTION

A voltage drop test is performed when the engine cranks slowly or not at all. When there is a cranking problem and the battery cables and connections have already been checked and repaired, you need to check the starter relays, solenoid, and circuits. The voltage drop test is used to determine if there is excessive resistance across a cable, component, or connection while current is flowing through it. Do not do these tests until you are certain the battery is good. It is much easier to check the battery, even if you think it is good, than to make voltage drop tests on starting system components. High resistance could cause a discharging battery or indicate a faulty alternator. The voltage drop test is measured using a multimeter.

EQUIPMENT AND SUPPLIES

- Vehicle with a 12-volt negative ground starter system
- Appropriate service manual
- Digital multimeter
- Clock, watch, or timer
- Basic hand tool set

☑ **NOTE:** You will need the help of an assistant for this Job Sheet.

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Interpret graphics and symbols
- Use content area vocabulary

	Yes	No
1. Crank the engine.	____	____
2. If the engine cranks slowly or does not crank at all, touch the positive voltmeter probe to the positive battery terminal and the negative voltmeter probe to the positive terminal at the starter. (Figure 1)	____	____

Math Application

- Use English and metric measures

Functional Math

- Make measurements

General Science

- Use scientific instruments
- Investigate/apply technology

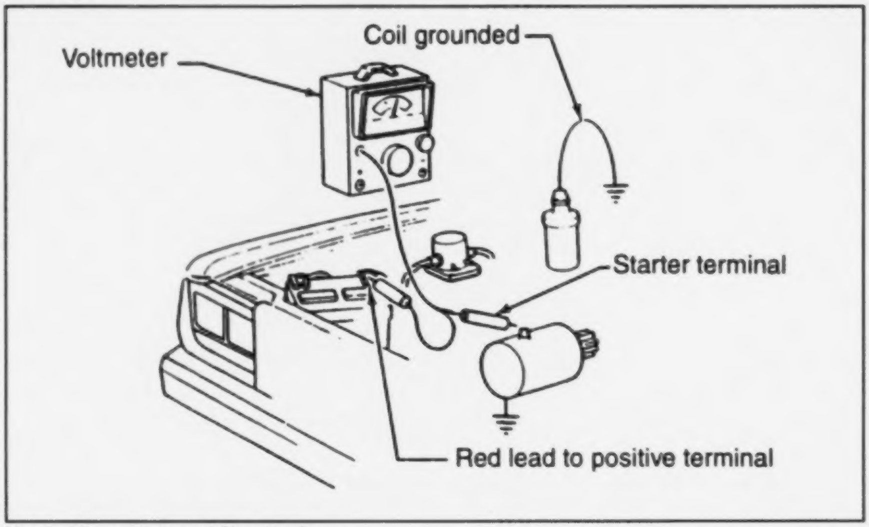
Cognitive Activities

- Transfer knowledge/training to new situations

Job Acquisition/ Development

- Master specific job task/procedure
- Practice good work habits/attitudes

FIGURE 1



Used with permission of Chrysler Corp.

Yes No

3. Have your assistant crank the engine while you look at the reading on the voltmeter; it should show zero. If the voltage drop (the difference between voltage shown BEFORE cranking and WHILE cranking) is more than .5 V, there is a problem in the circuit between the battery's positive terminal and the starter. ____ ____

☑ **NOTE:** A typical voltage drop should not exceed 0.2 volts across a wire or cable and 0.3 volts across a switch.

⚠ **NOTICE:** CRANKING THE STARTER for more than 10 seconds without allowing it to cool down for a minute will damage the starter. DO NOT CRANK THE STARTER FOR MORE THAN 10 SECONDS AT A TIME.

---

4. If there is a voltage drop, check for the voltage drop across each component of the circuit by leaving the positive probe of the voltmeter on the positive terminal of the battery and moving the negative probe of the voltmeter to the connection of each system component, in turn, checking the voltage drop as in Step 3. ____ ____

Yes No

☑ **NOTE:** When the voltage drop lessens, the last component tested before the voltage change is the problem.

5. If there is no significant voltage drop on the positive side of the circuit, check the negative side by touching the positive voltmeter probe to the starter frame and the negative voltmeter probe to the negative battery terminal. ____ ____

6. Have your assistant crank the engine as in Step 3; if the voltage drop is more than .2 V, there is a problem in the circuit between the battery's negative terminal and the starter. ____ ____

7. If this is the case, check for the voltage drop across each component of the circuit by leaving the negative voltmeter probe in contact with the negative battery terminal and moving the positive voltmeter probe to the connection of each system component, in turn, checking the voltage drop as in Step 4. ____ ____

☑ **NOTE:** When the voltage drop lessens, the last component tested before the voltage change is the problem.

8. Clean and tighten the connections of any component that tests bad and retest as in Step 4; if the problem still exists, the component must be replaced. ____ ____

9. If there is no voltage drop in any part of the circuit, and the starter still doesn't crank well, you must test and possibly replace the starter. (Job Sheet 6) ____ ____

10. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. ____ ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 6

SERVICING STARTING AND CHARGING SYSTEMS

2

Name ____________________

OBJECTIVE 15

Inspect, test, and repair or replace components and wires in the starter control circuit.

INTRODUCTION

Before inspecting, repairing, or replacing components and wires in the starter control circuit, you should always disable the ignition system. Check the starter relay (if present) and the solenoid for burned terminals or severely corroded or loose connections. Burned or corroded terminals normally, but not always, indicate a component which is damaged and must be replaced. If you find these problems, test the affected part. Check for loose connections or melted fusible links in the circuit between the battery and the starter and between the starter and the vehicle body. Tighten all loose connections and replace any melted fusible links.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 7

SERVICING STARTING AND CHARGING SYSTEMS

Name ____________________

OBJECTIVE 20

Inspect, adjust, and replace alternator drive belts, pulleys, and fans.

INTRODUCTION

If problems arise with an alternator, the problem usually is found in the alternator drive belts, pulleys, or fans because these parts are moveable and wear with use. These should be visually inspected for tightness, damage, or wear.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Vise
- Appropriate wrenches
- Replacement alternator drive belts, pulleys, and fans.
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

General Science
- Investigate/apply technology

Cognitive Activities
- Transfer knowledge/training to new situations

Yes No

1. Disconnect the battery negative cable. ____ ____
2. Disconnect the alternator wires. ____ ____

   ☑ **NOTE:** Some wires can be disconnected by removing a nut and washer while others have connectors which are unplugged.

3. Loosen the adjuster bolt and/or tensioner (if so equipped). ____ ____

   ☑ **NOTE:** Vehicles equipped with serpentive belts do not have adjuster bolts. ____ ____

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

	Yes	No
4. Loosen the drive belt by moving the alternator or the tensioner (if so equipped) in toward the engine.	____	____
5. Lift the drive belt from the alternator pulley.	____	____
6. Remove the loose adjuster bolt (if equipped) and mounting bolts by hand.	____	____
7. Lift the alternator from the vehicle.	____	____
8. Clamp the front rotor housing in a vise.	____	____
9. Hold the pulley shaft with an allen wrench and remove the drive pulley from the rotor shaft.	____	____
10. Remove the retainer nut and washer with an appropriate wrench.	____	____
11. Visually inspect the belts, pulleys, and fans for damage or wear.	____	____
12. Remove the old drive belt pulley and fan with an appropriate wrench.	____	____
13. Install a new drive belt pulley and fan.	____	____
14. Replace the drive pulley onto the rotor shaft. Clamp the front housing in the vise. Hold the pulley shaft with an appropriate wrench and tighten the retainer nut and washer.	____	____
15. Replace the alternator in the vehicle.	____	____
16. Replace the adjuster bolt (if equipped) and mounting bolts.	____	____
17. Replace the old drive pulley belt with a new drive pulley belt.	____	____
18. Tighten the adjuster bolt and mounting bolts.	____	____
19. Reconnect the alternator wires.	____	____
20. Reconnect the battery negative cable.	____	____
21. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 8 — SERVICING STARTING AND CHARGING SYSTEMS

2

Name ______________________________

OBJECTIVE 21

Inspect, repair, and replace charging circuit connectors and wires.

INTRODUCTION

Inspect charging circuit connectors and wires for tightness, wear, and damage when you perform any charging system component inspection, repair, or replacement. Refer to the vehicle service manual for any proper repair or replacement of the connectors and wires.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

OBJECTIVE SHEET

SERVICING ENGINE COOLING SYSTEMS

3

INTRODUCTION

The operation of an engine in a vehicle produces intense heat. The main purpose of the engine cooling system is to thermostatically regulate this temperature. Engine overheating will weaken, damage, or melt metal parts, decrease the efficiency of lubrication and engine performance, and cause higher volumes of nitrogen to be emitted through the exhaust system. In addition to decreasing lubrication efficiency and allowing excessive acids and hydrocarbons in the exhaust, engine overcooling will not allow the fuel to vaporize properly, decreasing engine efficiency.

Modern vehicles use a liquid cooling system, circulating a mixture of water and coolant in special passages inside and around engine parts to absorb the heat and maintain a constant operating temperature. Regular servicing of the cooling system will ensure the efficiency of the system. Any problems can be detected and corrected before damage is done to the engine.

PREREQUISITE

Unit 2, "Servicing Starting and Charging Systems."

FOCUS ASSIGNMENTS

FOCUS ASSIGNMENTS

PREREADING:	Read Mike Allen's commentary, "Wake Up, You Hoser," from *Popular Mechanics* magazine, June 1993, p. 89.
WRITING:	Write a short (one paragraph to one page) explanation of the proposed cause of hose failure and how a technician can check for this problem.

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment Sheet and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. List safety rules for working with automotive cooling systems.
2. Label the components of an engine cooling system indicated on an illustration.
3. Match the names of cooling system components to descriptions of their functions.
4. Label the parts of a radiator cap assembly indicated on an illustration.
5. Match the names of the parts of a radiator cap assembly to descriptions of their functions.
6. Perform cooling system pressure tests. (Job Sheet 1)
7. Check coolant; inspect and test a radiator, radiator cap, coolant recovery tank, and hoses. (Job Sheet 2)
8. Inspect, test, and replace a thermostat. (Job Sheet 3)
9. Name types of cooling system fans shown in illustrations.
10. Match the names of types of cooling system fans to descriptions of their operation.
11. Inspect, test, and replace a fan and fan components. (Job Sheet 4)
12. Diagnose cooling system problems. (Assignment Sheet)

OBJECTIVE 1

List safety rules for working with automotive cooling systems.

Required Activities/
Resources
– Explanation

Optional Activities/
Resources in
Instructor's Guide

Listen to your instructor's explanation of the importance of following the safety rules in this objective.

- Check the fan for cracked, bent, or damaged blades before running the engine with the hood open.

  ☑ **NOTE:** Replace the entire fan assembly if any damage is noted; a damaged fan may cause an imbalance in its operation and cause it to fly apart, injuring you or the vehicle. Stand behind the fan when it is operating, rather than in line with it, to prevent injury should a blade break and fly off.

- Disconnect the power to an electric fan before working near it.

  ☑ **NOTE:** Electric and/or thermostatically-controlled fans are activated by coolant temperature, so they may turn on unexpectedly even if the ignition switch is turned off.

- Never remove the radiator cap from a closed coolant system except to flush or test the system.

  ☑ **NOTE:** The pressurized system keeps the boiling point of the coolant at a lower temperature; removal of pressure will cause boiling instantly and may cause the hot coolant to spew forcefully out of the radiator. The hot coolant and steam will cause severe personal injury.

- Never remove the radiator cap if the radiator is warm to the touch.

  ☑ **NOTE:** You should also check the upper radiator hose for heat and tightness, which indicate the system is pressurized. Removing the cap in these circumstances can cause hot coolant and/or steam to escape and result in burns.

- Never perform cooling system service while the engine is hot or the coolant is under pressure.

  ☑ **NOTE:** Do not even open the hood of a vehicle if you can see or hear steam escaping from the engine area; wait until the engine has cooled before proceeding.

- When removing a radiator cap from a radiator that is cool to the touch, cover the cap with a thick rag or wear gloves to protect your hands from any steam or hot coolant which may still be present.

  ☑ **NOTE:** Turn the cap slowly ¼ to ½ turn, wait to release any remaining pressure, and stand back from the radiator. Only after all pressure has been released is it safe to remove the cap entirely, making sure you keep completely out of the way of any escaping coolant.

- Clean up coolant immediately if it is spilled.

  ☑ **NOTE:** Coolant is slippery and could cause accidents.

- Dispose of coolant properly according to the latest EPA standards.

- Do not swallow coolant, inhale its fumes, or allow it to touch your skin.

  ☑ **NOTE:** Coolant is a caustic liquid that can burn or irritate your skin. It is also poisonous and can cause illness or death if swallowed.

- Never reuse antifreeze containers for other purposes, especially for storage of consumable products.

- Do not spill coolant on hot engine systems.

  ☑ **NOTE:** Coolant is flammable in certain instances; if it comes into contact with a hot engine system, it could cause a fire.

OBJECTIVE 2

Required Activities/
Resources
– Explanations

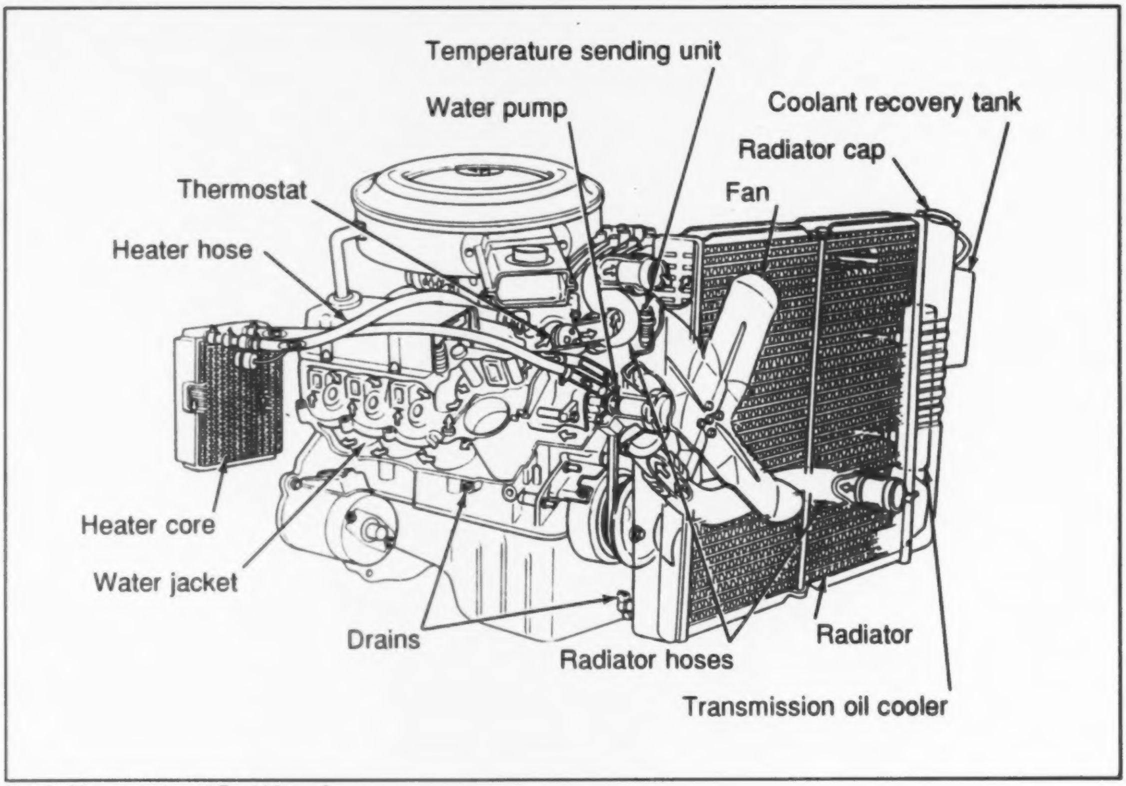
Optional Activities/
Resources in
Instructor's Guide

Label the components of an engine cooling system indicated on an illustration.

Listen to your instructor's explanation of how a cooling system operates.

Listen to your instructor's explanation of the two types of liquid cooling systems.

FIGURE 1



Temperature sending unit
Water pump
Coolant recovery tank
Radiator cap
Thermostat
Fan
Heater hose
Heater core
Water jacket
Drains
Radiator hoses
Radiator
Transmission oil cooler

Used with permission of Ford Motor Co.

☑ **NOTE:** Water mixed with coolant is circulated around the engine combustion chambers to carry away excess heat. Cooling systems may be either closed or open. *Closed systems* have a special radiator cap equipped with pressure and vacuum valves; these radiators are not opened except to flush or test the cooling system. They have an external reservoir connected to the radiator's overflow tube to allow for a visual inspection of the coolant level. *Open systems* use a conventional radiator cap and do not have an external reservoir to capture coolant forced out of the radiator; these systems are found mainly on older cars.

OBJECTIVE 3

Required Activities/
Resources
– Transparency Master 1

Optional Activities/
Resources in
Instructor's Guide

Match the names of cooling system components to descriptions of their functions.

Look at transparency 1 as your instructor explains the function of each part of the cooling system.

- **air spoiler/dam** — directs air flow to assist in cooling the engine and reduces the amount of air turbulence and drag under the vehicle

  ☑ **NOTE:** An air dam is a device designed and placed beneath the front bumper to direct the air flow so a vacuum is created which draws heat out of the engine compartment.

- **coolant** — circulates through the cooling system to carry heat away from the engine to the radiator for transfer to the outside air

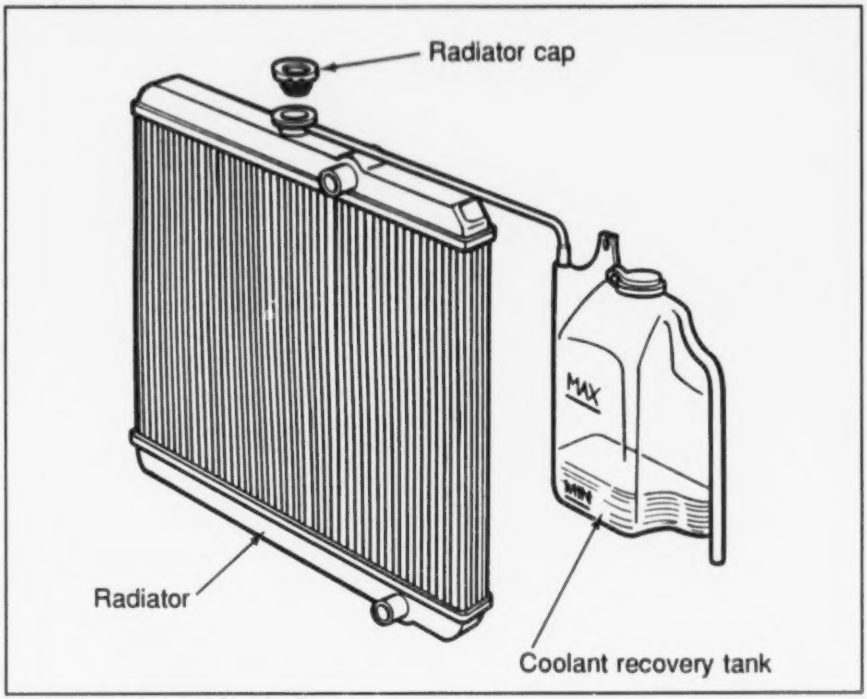
  ☑ **NOTE:** Cooling systems should always have a mixture of water and coolant, never only water or only coolant. A vehicle needs coolant even in the winter. Match the coolant used with the type of engine in the vehicle; some coolants are not safe for use with aluminum radiators and parts.

- **coolant recovery tank** (expansion tank) — minimizes the loss of coolant by catching coolant overflow when the system pressure increases during operation (Figure 2)

  ☑ **NOTE:** As the coolant in the system heats up, it expands and forces the pressure relief valve in the radiator cap open. The coolant then flows into the coolant recovery tank. When the engine is shut off, the coolant's temperature drops and its volume decreases. This creates a vacuum which causes the vacuum valve in the radiator cap to open. Atmospheric pressure can then force coolant back into the radiator. This process works to keep the cooling system filled with coolant at all times.

EXAMPLE:

FIGURE 2



Used with permission of Chrysler Corp.

- **drains** — provide a way to remove coolant from the radiator and engine block

  ☑ **NOTE:** Drains are not as common today on radiators and blocks as they once were. This is due in part to the fact that the lightweight materials used in modern radiator tanks will give way if too much pressure is used to open the drain. Drains are also easily clogged by rust and scale. It is much easier to drain the system by removing the lower radiator hose.

- **fan** — pulls air through the radiator core to dissipate the heat being carried by the coolant to the radiator

- **heater core** — provides heat for the passenger compartment heating system

  ☑ **NOTE:** The heater core is a small heat exchanger (radiator).

- **heater hoses** — carry coolant to and from the heater core and the cooling system
- **radiator** — allows heat from the coolant to be transferred to the outside air
- **radiator cap** (pressure cap) — maintains the correct pressure in the cooling system

  ☑ **NOTE:** When the cooling system is pressurized, the engine can run hotter without boiling the coolant.

- **radiator hoses** — carry coolant to and from the radiator to the engine
- **temperature sending unit** — provides a signal that indicates the temperature condition in the cooling system
- **thermostat** — controls the flow of coolant to maintain the correct engine operating temperature
- **transmission oil cooler** — cools the automatic transmission fluid

  ☑ **NOTE:** Transmission oil coolers are found on all vehicles with automatic transmissions. Many oil coolers are located inside the radiator at the bottom of downflow radiators and on the outlet side of crossflow radiators. Some vehicles have external transmission oil coolers.

- **water jacket** — contains and directs the flow of coolant through the inside of the engine block
- **water pump** — forces coolant through the engine and other cooling system components

OBJECTIVE 4

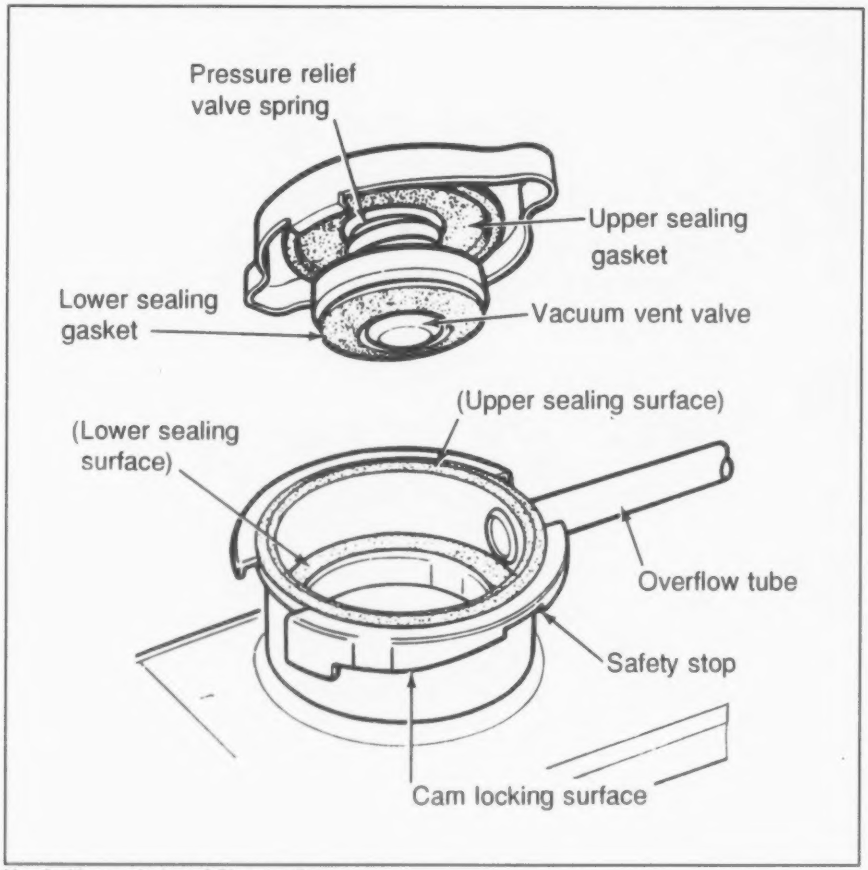
Required Activities/
Resources
– Explanation

Optional Activities/
Resources in
Instructor's Guide

Label the parts of a radiator cap assembly indicated on an illustration.

Listen to your instructor's explanation of the safety hazards and precautions to follow when removing a radiator cap.

FIGURE 3


Pressure relief valve spring
Upper sealing gasket
Lower sealing gasket
Vacuum vent valve
(Upper sealing surface)
(Lower sealing surface)
Overflow tube
Safety stop
Cam locking surface

Used with permission of Chrysler Corp.

NOTE: The radiator cap must match vehicle specifications. The pressure rating of the radiator cap required for the vehicle will be specified in the operator's manual; this must match the rating stamped on the radiator cap.

OBJECTIVE 5

Required Activities/ Resources
- Transparency Master 2
- Explanations

Optional Activities/ Resources in Instructor's Guide

Match the names of the parts of a radiator cap assembly to descriptions of their functions.

Look at transparency 2 as your instructor explains the functions of the parts of a radiator cap assembly.

Listen to your instructor's explanation of the role of the radiator cap in making the cooling system function properly.

Listen to your instructor's explanation of how pressure affects the boiling point of coolant.

- **pressure relief valve spring** — exerts internal pressure to seal the cooling system

- **vacuum vent valve** — protects the radiator from collapsing from the vacuum produced when the system cools down

- **upper sealing gasket** — provides a pressure seal between the radiator cap and the upper sealing surface of the radiator neck

  ☑ **NOTE:** The radiator cap must seal and fit properly to maintain pressure in the cooling system.

- **lower sealing gasket** — creates a seal between the radiator cap and the lower sealing surface

- **overflow tube** — carries coolant to and from the radiator and the coolant recovery tank

- **safety stop** — prevents the radiator cap from being removed before the pressure within the system is relieved

- **cam locking surface** — locks the radiator cap into position on the radiator neck, ensuring a good tight seal between the two

OBJECTIVE 6 **Complete Job Sheet 1.**

OBJECTIVE 7 **Complete Job Sheet 2.**

OBJECTIVE 8 **Complete Job Sheet 3.**

OBJECTIVE 9 **Name types of cooling system fans shown in illustrations.**

(See the names and illustrations under Objective 10.)

OBJECTIVE 10

Required Activities/
Resources
- Transparency Masters 3 and 4

Optional Activities/
Resources in Instructor's
Guide

Match the names of types of cooling system fans to descriptions of their operation.

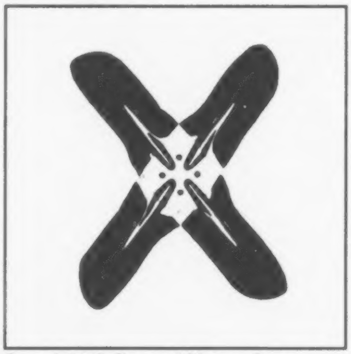
Look at transparencies 3 and 4 as your instructor explains the operation and characteristics of each type of fan.

- **Cross fan**

  Operation: The cross fan is belt-driven and turns at all times when the engine is operating.

  ☑ **NOTE:** A cross fan, sometimes called the *fixed blade fan*, operates even at high speeds when it is not needed, using engine horsepower unnecessarily. This is the least expensive type of fan.

FIGURE 4



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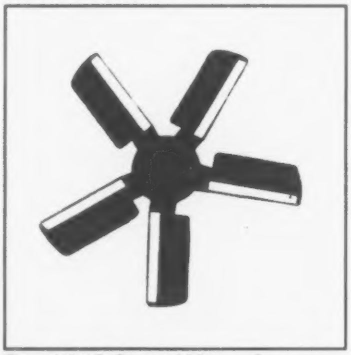
- **Power flex fan**

  Operation: A power flex fan's blades are flexible, bending at low speeds to draw maximum air flow through the radiator core and flattening at high speeds to save power and decrease noise.

FIGURE 5



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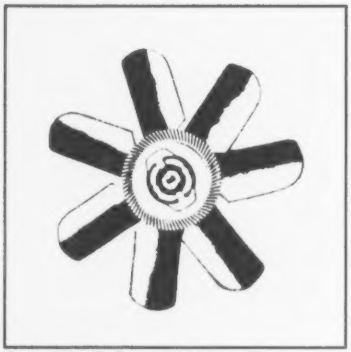
- **Thermo-clutch fan**

FIGURE 6



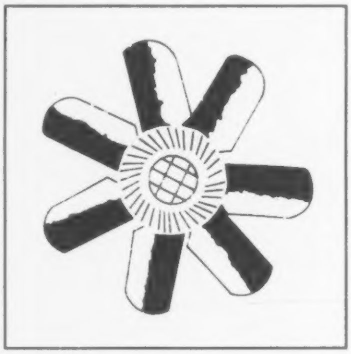
Copyright © General Motors Corp. Used with permission.

Operation: A thermo-clutch fan is controlled by a bimetal coil spring which engages the fan only when engine temperatures are high.

☑ **NOTE:** When the engine is cold, the thermo-clutch fan freewheels. As the air passing through the radiator heats up, the thermostatically-controlled spring activates an internal valve; silicone oil flows from a reservoir into the working chamber and engages the clutch. Then as the air passing through the radiator cools, the silicone oil returns to the reservoir and the clutch disengages. When sufficient air moves through the radiator during the vehicle's movement, the thermo-clutch fan also responds to engine rpm and allows some slippage in the fluid chamber.

- **Viscous-clutch fan**

FIGURE 7

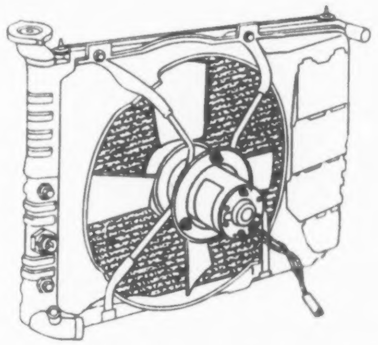


Operation: The silicone oil in a viscous-clutch fan thickens and engages the fan only when the engine is hot.

☑ **NOTE:** Silicone oil surrounds an impeller and a stator. The action of the viscous clutch keeps the fan at or below a specified speed to conserve horsepower at high engine speeds.

- **Electric fan**

FIGURE 8



Used with permission of Chrysler Corp.

Operation: An electric fan is operated by a heat-sensitive switch or sensor that turns it on and off.

☑ **NOTE:** The sensor (located in different places on different vehicles) turns the fan motor on only when the fan is needed and turns the motor off if the engine begins to cool down too much. The fan can either push or pull air while some fan systems will both push and pull air. On cars with air conditioning, the fan motor may run as long as the air conditioner is on. This type of fan is found on many late model cars, especially those with front-wheel drive.

OBJECTIVE 11 **Complete Job Sheet 4.**

OBJECTIVE 12 **Complete the Assignment Sheet**

ASSIGNMENT SHEET

SERVICING ENGINE COOLING SYSTEMS

3

Name ______________________________ Score __________

OBJECTIVE 12

Diagnose cooling system problems.

Required Activities/ Resources
- Handouts 1 and 2
- Explanation

Read Handout 1, Troubleshooting the Cooling System, and Handout 2, Cooling System Diagnostic Chart, to help you complete this Assignment Sheet.

Optional Activities/ Resources in Instructor's Guide

Listen as your instructor explains the information found in these Handouts.

EQUIPMENT AND SUPPLIES

- Handout 1, Troubleshooting the Cooling System
- Handout 2, Cooling System Diagnosis Chart

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

General Science
- Investigate/apply technology

Cognitive Activities
- Identify critical elements/issues
- Draw conclusions
- Transfer knowledge/training to new situations

You are a recent graduate of the Vo-Tech School and know the importance of properly servicing the engine cooling system in a vehicle to ensure proper performance. You have just been hired as a technician at A-1 Service Center. All of the other technicians in the shop are working on tight deadlines to have vehicles ready for their owners to pick up in a few hours.

John Jones brings his 1986 vehicle into the shop and explains that his engine overheats continually and overall performance has decreased.

You begin to check the vehicle thoroughly to diagnose the problem. You make the following judgments during your checks; are your decisions correct? Put a "Y" in the blank if the answer to the question is "Yes;" put an "N" in the blank if the answer is "No."

____ 1. You notice that the radiator has leaves and bugs all over the front of it, so you decide to wash it before working around it so you will not get dirty. You believe this will have no effect on the problem the customer described. Are you correct?

____ 2. You check around the radiator cap and opening to the coolant recovery tank and see no coolant leaks. You assume the problem could not be a coolant leak. Are you correct?

Job Acquisition/
Development
- Master specific job task/procedure

____ 3. You check the oil level and find a milky white solution. You determine there may be a faulty cylinder head gasket or a cracked cylinder head or block. Are you correct?

____ 4. You find bubbles in the coolant and assume this could be caused by a damaged head gasket, cracked block, or cracked cylinder head. Are you correct?

____ 5. You find rust and corrosion in the system so you decide to check further for poor coolant flow. Could this also cause overheating?

____ 6. You find a loose fan belt and know that this would affect the air flow through the system. Would it also have an effect on the coolant flow?

____ 7. Could the loose fan belt you found cause the engine to overheat?

____ 8. You find that the thermostat is stuck in the open position and determine that this may have caused the engine to overheat. Are you correct?

____ 9. You determine there is no need to check the exhaust system because it is in no way connected with the engine cooling system. Are you correct?

____ 10. When you start the engine to perform some of your checks, you hear a squeaking noise. You assume this is an engine problem and would have nothing to do with the cooling system. Are you correct?

JOB
SHEET 1

SERVICING ENGINE COOLING SYSTEMS

3

Name ______________________________

OBJECTIVE 6

Perform cooling system pressure tests.

INTRODUCTION

The life of the engine depends upon the cooling system's ability to remove heat quickly but at a controlled rate. Each part of the system must do its job. If it doesn't, the engine may run too hot or too cold. The Engine Performance Technician must be able to recognize and correct cooling system problems before they lead to serious engine damage.

Cooling system problems can be categorized as coolant leaks, overheating, and overcooling. Coolant leaks are the result of cracks, ruptures, or faulty radiator caps that allow coolant to escape from the system. Overheating occurs when the engine's operating temperature is too high. Signs of overheating are warning light on, temperature gauge showing hot, and/or coolant and steam blowing out of the overflow. Overcooling occurs when the engine fails to reach full operating temperature. The signs are poor or sluggish engine performance.

A visual inspection will frequently reveal the problem; however, if it does not, then you should consider using one of the following tests:

- **Pressure test** — The purpose of this test is to quickly locate leaks in the cooling system. A pressure test includes tests of both the system and the radiator cap. Most pressure losses occur through a radiator cap that does not maintain a proper seal.

- **Combustion leak test** — The purpose of this test is to determine if there are any combustion or compression leaks entering the cooling system because of a defective head gasket or a cracked block.

One available product, the *Cooling System Analyzer*, is a kit which can troubleshoot the entire cooling system, including faulty thermostats, cooling fan switches, clutch fans, and coolant sensors. It can also diagnose radiator and water jacket leaks, head cracks, and blown head gaskets. Leaks in the water pump, hoses, radiator, heater core, and control valve can be identified while the system is under pressure. The analyzer can also provide immediate engine coolant temperature readings which enable you to determine the precise operating range of the cooling fan and thermostat.

EQUIPMENT AND SUPPLIES

- Vehicle with a liquid-cooling system
- Appropriate service manual
- Cooling system pressure tester and adapters
- Soap and water solution
- Pencil and paper
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

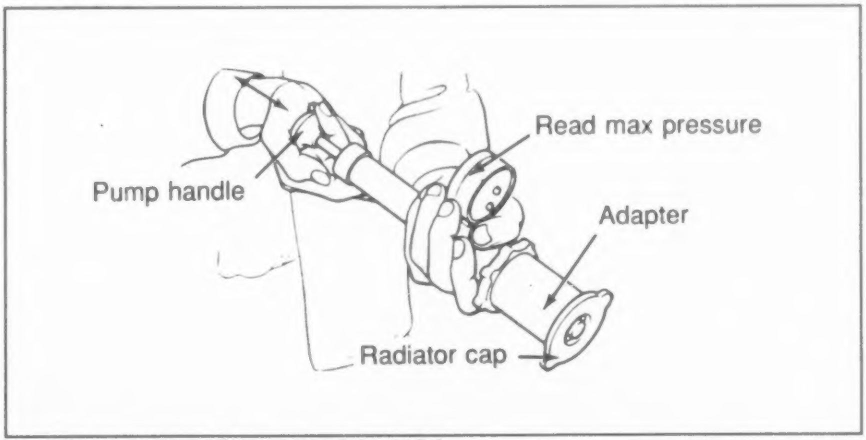
Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret graphics and symbols

Perform a pressure test Yes No

1. Install the radiator cap on the cooling system pressure tester. (Figure 1) ____ ____

FIGURE 1



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Math Application
- Use English and metric measures

Data Analysis and Display
- Collect/record data

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Physical Science
- Investigate/apply physical laws

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

2. Pump the tester slowly to pressurize the cap. ____ ____

☑ **NOTE:** Fast pumping can cause inaccurate readings.

3. Watch the pressure gauge, and note the reading when the pressure stops increasing. ____ ____

☑ **NOTE:** This is the point where the cap's pressure relief valve opens.

4. Release the tester pressure, and repeat steps 2 and 3 again twice. ____ ____

5. Compare the test results to the system pressure specifications in the service manual. ____ ____

6. If the pressure reading is below the minimum specified pressure or 2 to 4 psi above the maximum pressure, replace the radiator cap. ____ ____

7. If the radiator cap pressure is within specifications, perform the radiator and system test. ____ ____

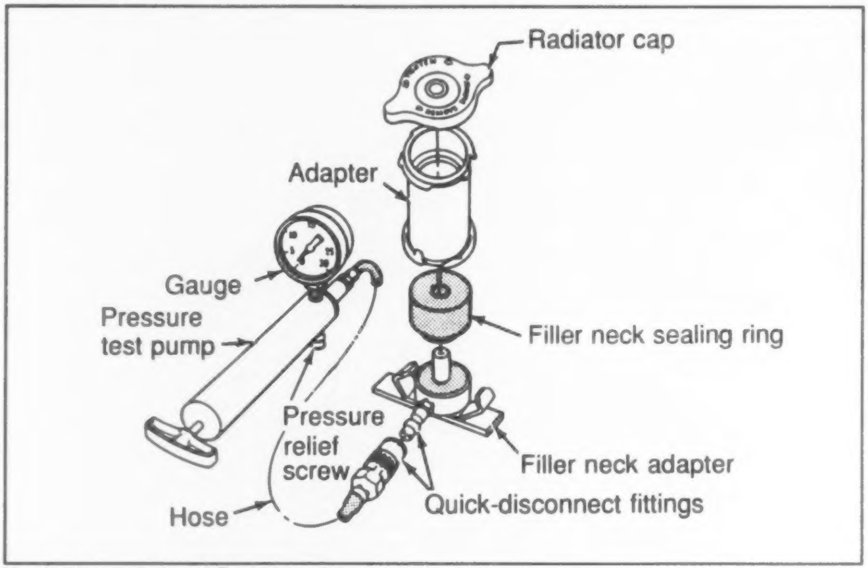
8. With the engine cold, remove the cap from the radiator and add water or coolant if necessary. ____ ____

☑ **NOTE:** The coolant level should be $\frac{3}{4}$ inch below the neck of a downflow radiator, or $2\frac{1}{2}$ inches below the neck of a cross-flow radiator.

9. Attach the cooling system pressure tester to the radiator filler neck. ____ ____

☑ **NOTE:** Follow the manufacturer's instructions regarding how to attach the pressure tester. If necessary, use a filler neck adapter to seal the overflow tube opening. (Figure 2)

FIGURE 2


Radiator cap
Adapter
Gauge
Pressure test pump
Filler neck sealing ring
Pressure relief screw
Filler neck adapter
Quick-disconnect fittings
Hose

Used with permission of Ford Motor Co.

	Yes	No
10. Use the vehicle's service manual to determine the cooling system's pressure specifications.	____	____
11. Pump the tester until the pressure gauge indicates the specified system pressure.	____	____

⚠ **NOTICE:** TOO MUCH PRESSURE can damage the radiator. DO NOT OVERPRESSURIZE THE SYSTEM.

---

12. Watch the gauge for at least two minutes. It should hold steady.	____	____
13. If the pressure drops, pump the tester to maintain pressure while you inspect the system for leaks.	____	____
14. Apply a soap and water solution to the radiator seams and check for bubbles.	____	____

☑ **NOTE:** Bubbling is an indication of a leak.

15. Apply the soap and water solution to each of the following, one at a time, and check for bubbles: hose fittings, gaskets under the water pump, and engine core plugs.	____	____

Yes No

16. If a leak is found, tighten, repair, or replace the parts as needed. ____ ____

17. Examine the oil on the end of the dipstick and the oil filler cap for water droplets or signs of coolant. ____ ____

☑ **NOTE:** When water, antifreeze, and oil mix, the solution turns milky white.

18. If signs of water or coolant are present in the crankcase, you may have a faulty cylinder head gasket, or a cracked cylinder head, block, or intake manifold.. Confirm this by performing the combustion leak test. ____ ____

☑ **NOTE:** A faulty intake manifold is more commonly found in V-6 engines.

19. If a leak is not found, test for internal leaks with the combustion leak test. ____ ____

PROCEDURE

Job Acquisition/ Development
- Master specific job task/procedure

Perform a combustion leak test

1. Carefully remove the radiator cap. ____ ____

⚠ **WARNING:** REMOVAL OF THE RADIATOR CAP on a hot engine could cause the coolant to boil and spurt out of the filler neck, causing severe burns. REMOVE THE RADIATOR CAP SLOWLY TO RELEASE PRESSURE BUILDUP.

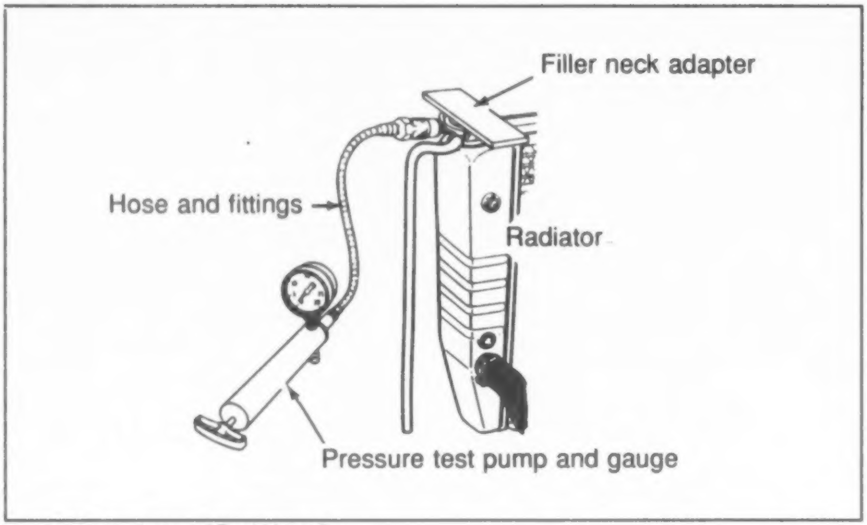
---

2. Start the engine, allow it to run until it reaches normal operating temperature, then turn it off. ____ ____

3. Following manufacturer's instructions, attach the radiator pressure tester to the radiator with the relief valve open. (Figure 3) ____ ____

☑ **NOTE:** If necessary, use a sealing ring adapter in the filler neck to seal off the overflow tube.

FIGURE 3



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Yes No

4. Look on the radiator cap and note the cap's rating. ____ ____

☑ **NOTE:** If the rating cannot be found on the radiator cap, check the vehicle service manual.

5. Close the tester relief valve and watch the gauge. ____ ____

⚠ **NOTICE:** TOO MUCH PRESSURE can damage the radiator. DO NOT ALLOW THE PRESSURE TO BUILD UP BEYOND THE RADIATOR CAP RATING.

---

6. If the gauge reading rises quickly, there is a large exhaust leak into the system. ____ ____

7. If the gauge rises slowly, the thermostat may be stuck closed. ____ ____

8. If the gauge reading does not rise, operate the pump and apply enough pressure to the system to bring it within the pressure range of the radiator cap. ____ ____

☑ **NOTE:** Do *not* exceed the maximum rating on the radiator cap.

	Yes	No
9. If the needle on the gauge vibrates when the radiator cap rating is reached, there is a small combustion leak.	____	____
10. If the needle remains steady at the radiator cap rating, there is no leak.	____	____
11. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 2

SERVICING ENGINE COOLING SYSTEMS

3

Name ______________________________

OBJECTIVE 7

Check coolant; inspect and test a radiator, radiator cap, coolant recovery tank, and hoses.

INTRODUCTION

Antifreeze should be checked and changed at regular intervals. After prolonged use, antifreeze will break down and become very corrosive. It can lose its rust preventive properties, and the cooling system can become clogged with rust.

Vehicle manufacturers and coolant companies recommend that coolant be changed after 12 to 24 months. You should check the vehicle's service manual and the recommendation on the coolant you install. A coolant change every 18 months is usually satisfactory. Regardless of the recommended service interval for a vehicle, a cooling system should be drained and refilled if:

- the coolant is contaminated or has lost its effectiveness
- the system is clogged
- the engine continues to overheat after passing all other system tests

Disposal of used coolant presents pollution problems. Many repair shops now recycle coolant. Be sure you know the procedures in use at the shop where you work.

The radiator is one of the major components of any liquid-cooling system. It is here that heat in the coolant is released to the atmosphere. The radiator does this by circulating the hot coolant through a series of small tubes surrounded by fins and air passages. Then as a large volume of air is passed through the air passages, heat is transferred from the coolant through the fins to the air.

When overheating problems occur and the system is not leaking, check the radiator and the pressure cap. They are common sources of overheating problems. The pressure cap could have defective seals allowing pressure to escape from the system, or the radiator might be clogged preventing the proper air or coolant flow.

Most vehicles have at least five hoses in the cooling system. Two small-diameter hoses supply hot coolant to the passenger compartment heater core. A short, small-diameter bypass hose allows the coolant to circulate within the engine while the engine warms up to operating temperature. Two large-diameter hoses transport the coolant from the water pump to the radiator and back into the engine block.

Flexible hoses are used in connecting the cooling system components because they can withstand vibration better than rigid tubing. However, flexible radiator hoses have disadvantages too.

Radiator hoses can be damaged by air, heat, and water in two ways:

- Hardening or cracking — destroys hose flexibility, causes leakage, and allows small particles of rubber to clog the radiator
- Softening and swelling — produces hose failure and hose rupture

Eventually rubber hoses deteriorate, develop leaks, or collapse internally and must be replaced. Some automotive authorities recommend replacing all hoses every two years while others feel this is too frequent. Regardless of which theory you choose to follow, examine all hoses at least twice a year for possible replacement or tightening.

Guidelines for hose replacement:

- Use replacement hoses of the correct inside diameter.
- Do *not* use a rigid hose between the radiator and the engine.

  ☑ **NOTE:** If a rigid hose is used, the normal movement of the engine could cause the radiator fittings to crack and leak.

- Use either a soft, molded type hose or a flexible accordion type hose between the radiator and the engine.
- If the hose placed on the vehicle by the manufacturer contains a spiral wire inside to prevent collapse, ensure the same type of hose is used for replacement.
- If the spiral wire is badly rusted, replace the hose.
- Never reuse wire clamps.

EQUIPMENT AND SUPPLIES

- Vehicle with liquid-cooling system
- Appropriate service manual
- Wire brush, small file, or resurfacing tool, if needed
- Bottle brush
- Soap and water solution
- Water hose and source of water
- Cooling system pressure tester
- Coolant hydrometer or refractometer
- Coolant, if needed
- Coolant drain pan
- Universal plugs
- Transmission fluid
- Appropriate replacement hoses
- Non-hardening gasket cement
- Knife
- Aircraft type clamps
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Check coolant Yes No

1. Remove the radiator pressure cap if the system is cool. ____ ____

⚠ **WARNING:** REMOVAL OF THE RADIATOR CAP on a hot engine could cause the coolant to boil and spurt out of the filler neck, causing severe burns. REMOVE THE RADIATOR CAP SLOWLY TO RELEASE PRESSURE BUILDUP.

---

2. Check for rust, oil, scale, or transmission fluid by rubbing your finger inside the radiator filler neck. ____ ____

   ☑ **NOTE:** The presence of oil indicates there is an internal engine leak. The presence of transmission fluid indicates a leaking oil cooler.

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

3. Find out how long the antifreeze solution has been in service. ____ ____

4. Start the engine, allow it to reach normal operating temperature, then turn it off. ____ ____

5. Use a coolant hydrometer or refractometer to determine the level of antifreeze protection. ____ ____

   ☑ **NOTE:** When using either of these testers, follow manufacturer's instructions.

6. If the coolant is old, contaminated, or has lost its protective qualities, it will have to be replaced. ____ ____

7. Examine the coolant for rust. ____ ____

   ☑ **NOTE:** A light brown color indicates rust in the system. A dark milky brown color indicates a badly rusted system.

8. If there is rust in the system, the system must be flushed with water before the coolant is replaced. ____ ____

9. If the system is badly rusted, the radiator may need to be replaced or cleaned with a chemical cleaner. Seek your instructor's advice if you think the system is badly rusted. ____ ____

   ☑ **NOTE:** If you need to flush the radiator with a chemical radiator cleaner, you should not drain the system before performing the chemical flushing. Chemical radiator cleaners are extremely caustic and can cause radiator damage, even if used correctly. There are several types of chemical radiator cleaners and the instructions on using them vary. Whichever cleaner you choose, be sure to follow the instructions exactly to minimize damage to the cooling system.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Inspect and test the radiator, radiator cap, and coolant recovery tank

1. Visually inspect the outside of the radiator for debris such as bugs, leaves, and road dirt. ____ ____

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Physical Science
- Investigate/apply physical laws

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

☑ **NOTE:** If needed, use a water hose to wash the debris out of the core. Spray water from the back side of the radiator to push the debris out the front.

2. Check the fan shroud for cracks and missing fasteners. Repair or replace as needed. ____ ____

3. Inspect the radiator cap for cracks or tears in the cap seal. Replace the cap if needed. ____ ____

4. Check the filler neck sealing surfaces for nicks or dents. ____ ____

5. Clean these surfaces with a wire brush, a small file, or a resurfacing tool if needed. ____ ____

6. Pressure test the radiator cap. (Job Sheet 1) ____ ____

☑ **NOTE:** The cap should release air at the pressure point stamped on the cap. It should also hold that pressure for at least one minute. If not, replace the cap.

7. Inspect the coolant, and use a coolant hydrometer to test its level of freeze protection. ____ ____

☑ **NOTE:** If the coolant is in good condition, save it for reuse.

8. Drain the cooling system into a drain pan. ____ ____

9. Use the service manual to determine what parts or accessories you must move for radiator clearance before loosening or removing any parts. Check the following:
   - ☐ Fan shroud and air shield ____ ____
   - ☐ Transmission or oil cooler lines at the radiator outlet tank ____ ____
   - ☐ Air conditioning condenser ____ ____
   - ☐ Fan (electric or belt-driven) ____ ____
   - ☐ Coolant temperature switches and connections in the radiator inlet tank ____ ____
   - ☐ Coolant recovery tank and overflow tube ____ ____

Yes No

10. Inspect the radiator hoses. ____ ____

11. Remove the upper and lower radiator hoses and the overflow tube. ____ ____

☑ **NOTE:** If they are in good condition, remove them carefully. If the hoses are to be replaced, you may want to cut them off the radiator and engine to save time.

12. Remove the coolant recovery tank from its brackets. ____ ____

13. If the radiator contains a transmission cooler, disconnect the transmission cooler lines from the radiator. ____ ____

14. Plug the lines from the transmission with universal plugs. ____ ____

15. Remove the fan and fan shroud. ____ ____

☑ **NOTE:** On some vehicles, it may not be necessary to remove the fan. Check your service manual for details.

16. Remove the capscrews that hold the radiator to the front bulkhead of the engine compartment. ____ ____

17. Carefully lift the radiator straight up and out, taking care not to dent the cooling fins or tubes. ____ ____

18. Inspect the radiator for defects. ____ ____

☑ **NOTE:** The fin metal should be firm and should not flake off when rubbed. The fins should also be firmly attached to the tubes.

19. Inspect the radiator's mounting points. ____ ____

20. If the radiator is damaged, repair or replace it. ____ ____

Yes No

☑ **NOTE:** Most radiator repairs are performed by a radiator shop. They have the facilities to properly disassemble, rod out (clean), solder (repair) and pressure test a radiator. Few Engine Performance Technicians try to fix a radiator in their own shop.

21. Inspect the coolant recovery tank for cracks. Repair or replace it if needed. ____ ____

22. Use a bottle brush and soap and water to clean the coolant recovery tank; rinse it. ____ ____

☑ **NOTE:** Make sure the fill markings on the tank are visible.

23. Reinstall the radiator, following service manual procedures. ____ ____

24. Install the fan and fan shroud, following service manual procedure. ____ ____

25. Reinstall the coolant recovery tank, following service manual procedure. ____ ____

26. Connect all hoses and lines. ____ ____

27. Ensure all drain points are closed. ____ ____

28. Refill the radiator with coolant and check for leaks. ____ ____

29. Refill the transmission with fluid. ____ ____

30. Start the engine and allow it to reach normal operating temperature. ____ ____

31. Add coolant as needed. ____ ____

32. Turn off the engine. ____ ____

33. Reinstall the radiator cap. ____ ____

34. Restart the engine and allow it to reach normal operating temperature. ____ ____

35. Turn off the engine and check for leaks. ____ ____

36. Repair leaks as necessary. ____ ____

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret graphics and symbols

Functional Math
- Make measurements

General Science
- Investigate/apply technology

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

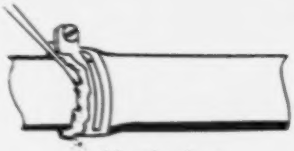
Inspect and test radiator hoses.

⚠ **WARNING:** FANS CAN COME ON UNEXPECTEDLY and cause severe cuts. Electric fans may start at any time regardless of whether the ignition switch is on or off. DISCONNECT THE FAN RELAY OR THE BATTERY GROUND CABLE ON VEHICLES WITH ELECTRIC FANS TO KEEP THE FAN FROM STARTING WHILE YOU WORK IN THE ENGINE COMPARTMENT.

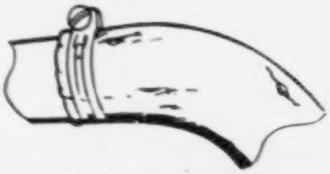
---

1. Visually check all hoses for signs of cracks, bulges, cuts, deterioration, or damage. (Figure 1) Yes ____ No ____

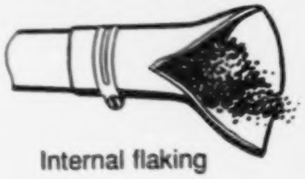
FIGURE 1



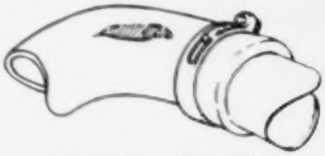
Hardening



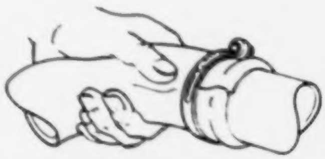
Cracks and breaks



Internal flaking



Chafed or burned



Oil-soaked or swollen

Used with permission of Gates Rubber Co. and Ford Motor Co.

Yes No

2. Inspect all hoses for loose or broken clamps. ____ ____

3. Tighten loose clamps or replace defective clamps. ____ ____

4. Run your hand over the hoses and check for a hose that is either in friction contact with another vehicle component or in contact with the hot surface of an adjacent component. ____ ____

☑ **NOTE:** A hose that is in friction contact with another component could become chafed. A hose that is in contact with the hot surface of another component will show burn marks where contact has been made.

5. Squeeze the hoses and check for a hose that is either hard and brittle, soft, spongy, or swollen. ____ ____

☑ **NOTE:** If the hose is hard and brittle, it is either too old or has been exposed to heat for too long. If the hose is soft or spongy, it has probably deteriorated internally. If the hose is swollen, it is weak and may rupture.

6. Bend the heater hoses to check for surface cracking, abnormal swelling, and hardness. ____ ____

7. Replace hoses showing any of the above conditions. ____ ____

PROCEDURE

Job Acquisition/ Development
- Master specific job task/procedure

Replace engine cooling system and heater system hoses

Yes No

1. Remove the radiator cap if the system is cool. ____ ____

⚠ **WARNING:** REMOVAL OF THE RADIATOR CAP on a hot engine could cause the coolant to boil and spurt out of the filler neck, causing severe burns. REMOVE THE RADIATOR CAP SLOWLY TO RELEASE PRESSURE BUILDUP.

Yes No

2. Position the coolant drain pan under the cooling system drain. ____ ____

3. Open the drain and drain the coolant. ____ ____

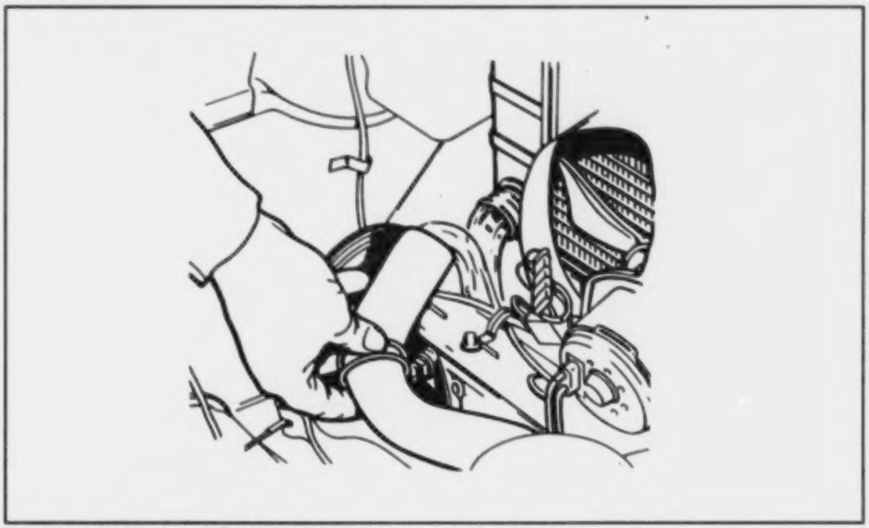
   ☑ **NOTE:** If the coolant is clean, save it for reuse.

4. Loosen the hose clamps. ____ ____

5. Twist and pull the hose off fitting. (Figure 2) ____ ____

   ☑ **NOTE:** Hoses are often very difficult to remove - they fit tightly and are frequently glued on. If a new hose is to be installed, cut a slit in the end of the old hose to aid in removal. However, radiator hose necks are usually made of plastic, fiberglass, brass, or copper, and these materials are easily gouged or damaged. Have your instructor show you how to remove a hose that is stuck.

FIGURE 2

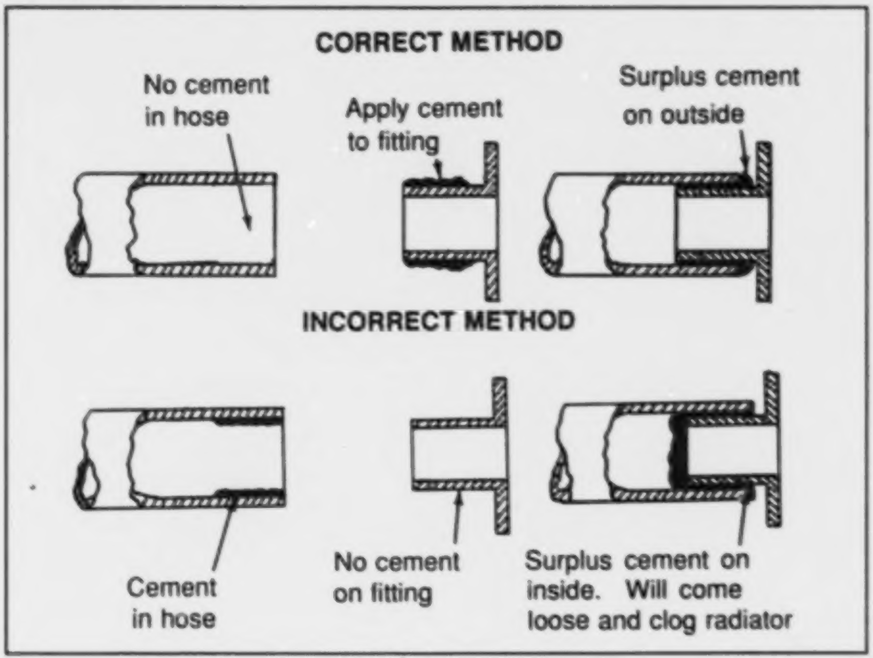


Used with permission of Ford Motor Co.

6. Clean the hose fittings. ____ ____

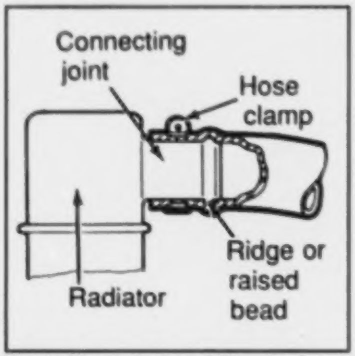
7. Coat the fittings with a non-hardening gasket cement. (Figure 3) ____ ____

FIGURE 3


CORRECT METHOD
No cement in hose
Apply cement to fitting
Surplus cement on outside
INCORRECT METHOD
Cement in hose
No cement on fitting
Surplus cement on inside. Will come loose and clog radiator

	Yes	No
8. Install the new hose.	____	____
9. Position the hose clamps over the metal hose fitting. (Figure 4)	____	____

FIGURE 4


Connecting joint
Hose clamp
Radiator
Ridge or raised bead

Used with permission of Chrysler Corp.

10. Tighten the clamps.	____	____
11. Install coolant.	____	____
12. Make a pressure test. (Job Sheet 1)	____	____

		Yes	No
13.	Check for leaks.	____	____
14.	Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 3

SERVICING ENGINE COOLING SYSTEMS

3

Name ______________________________

OBJECTIVE 8

Inspect, test, and replace a thermostat.

INTRODUCTION

The thermostat controls coolant flow in the system and helps maintain the correct engine temperature. On most vehicles the thermostat is in line between the engine block and the large diameter inlet hose to the radiator. When the thermostat is closed, only the coolant inside the engine is warmed. As the coolant heats up, the thermostat begins to open. When the engine is warm, the thermostat will open completely and allow the coolant to circulate through the radiator and the engine.

When the thermostat is not operating properly, the engine may run either too hot or too cool. If the thermostat opens at a lower temperature than is specified, the engine may not reach normal temperature and would continually run rich—using unnecessary fuel. On the other hand, if the thermostat sticks closed or open at a temperature that is too high, the engine could overheat.

EQUIPMENT AND SUPPLIES

- Vehicle with liquid-cooling system
- Appropriate service manual
- Rubber hammer
- Pencil and paper
- Syringe
- Cooking pot
- Water
- Hot plate
- Wire
- Thermometer or thermostat tester
- Putty knife
- Rag
- RTV sealant or appropriate gasket
- Coolant drain pan
- Torque wrench
- Feeler gauge
- Appropriate thermostat
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret graphics and symbols

Math Application
- Use English and metric measures

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Physical Science
- Investigate/apply physical laws

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

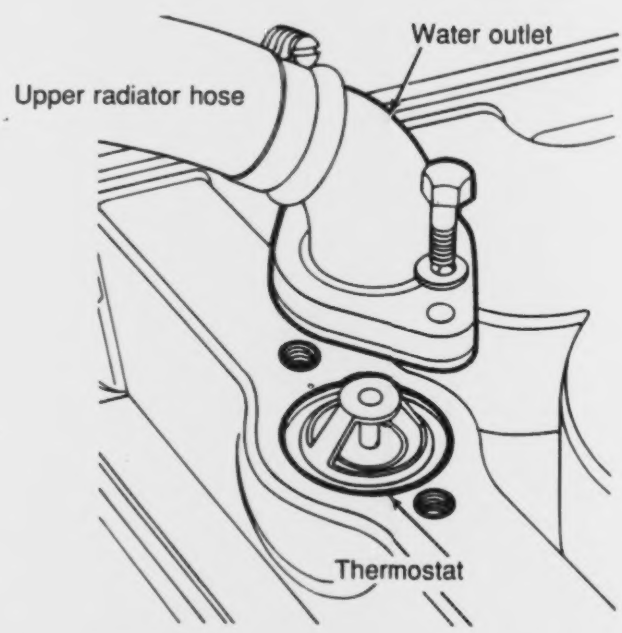
Inspect, test, and replace a thermostat, by-pass, and housing Yes No

1. On a cool engine, check for pressure and remove the radiator cap. ____ ____
2. Use a syringe to remove coolant until it is below the thermostat housing level. ____ ____

   ☑ **NOTE:** Save the coolant if it is clean.

3. Remove the bolts attaching the thermostat housing. (Figure 1) ____ ____

FIGURE 1



Used with permission of Chrysler Corp.

4. Remove the thermostat housing or housing cap. ____ ____

   ☑ **NOTE:** If necessary, use a rubber hammer to tap the housing free.

Yes No

5. Remove and rinse the thermostat. ____ ____

6. Visually inspect the thermostat for breaks, corrosion, and improper sealing. ____ ____

☑ **NOTE:** The thermostat is sealing properly if the plate is making close and complete contact with the upper sealing surface.

7. Replace the thermostat if any of these are present. ____ ____

8. Determine the operating (opening) temperature of the thermostat. ____ ____

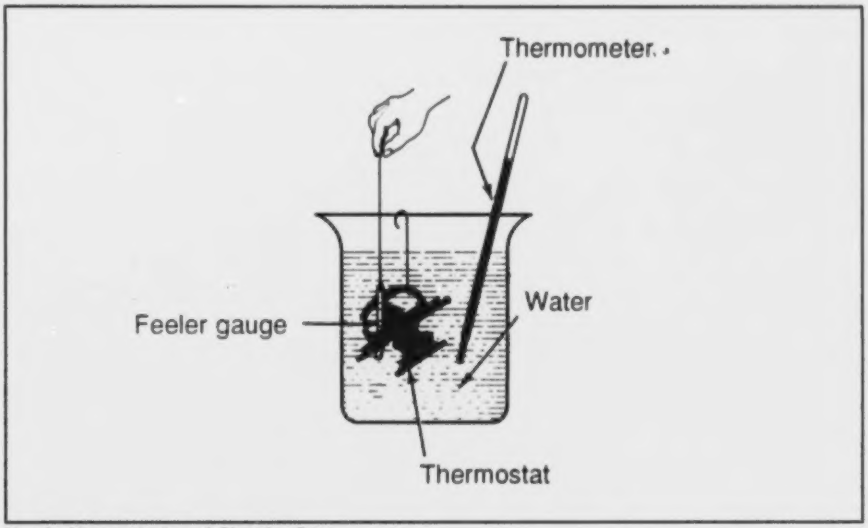
☑ **NOTE:** The temperature rating is usually stamped on the engine side of the thermostat. It may be shown as either degrees fahrenheit (F) or centigrade (C). The number stamped on it is the appropriate opening temperature.

9. Replace the thermostat if it does not match the manufacturer's specifications as to type and temperature. ____ ____

10. Suspend the thermostat, pellet down, in a special thermostat tester or in a cooking pot or heat-proof container of water with a thermometer. ____ ____

☑ **NOTE:** Do not let the thermostat or the thermometer touch the sides or bottom of the container. Hang them on a wire if necessary. (Figure 2)

FIGURE 2



Used with permission of Chrysler Corp.

Yes No

11. Place the pot on a hot plate and gradually raise the temperature of the water, stirring the water as the temperature increases. ____ ____

12. Make a note of the point at which the thermostat begins to open. ____ ____

☑ **NOTE:** It should begin to open within 5° to 10°F (2.8° to 5.6°C) plus or minus of the temperature rating stamped on the thermostat.

13. Apply additional heat to ensure the thermostat will open fully and make a note of the point when this occurs. ____ ____

☑ **NOTE:** The thermostat should be fully open at a temperature around 20° to 24°F (–6.7° to –4.5°C) above the opening temperature.

14. Turn off the heat and let the water cool. ____ ____

15. Note the temperature at which the thermostat closes. ____ ____

☑ **NOTE:** The temperature at which it closes should be equal to or slightly less than the opening temperature.

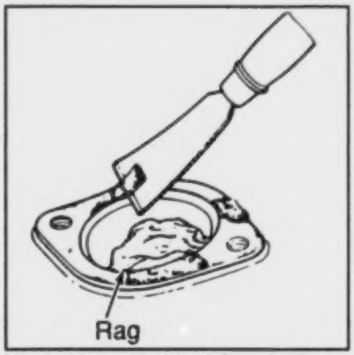
16. Replace the thermostat if it does not meet specifications. ____ ____

Yes No

17. Use a putty knife to clean the mating surfaces of the thermostat housing and its mounting surface. (Figure 3) ____ ____

☑ **NOTE:** Place a shop cloth in the hole to prevent scrapings from falling in the water.

FIGURE 3



Used with permission of Chrysler Corp.

18. Clean out the thermostat pocket and housing. ____ ____

☑ **NOTE:** If it is rusty, clean and flush it.

19. Inspect the housing to ensure it is not warped. ____ ____

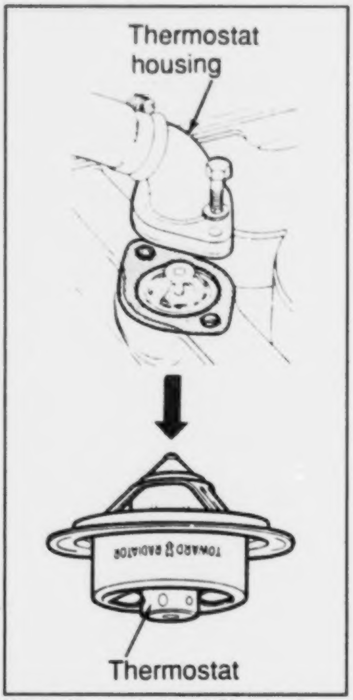
☑ **NOTE:** Place the housing on a flat surface and check for gaps between the housing and the surface. If it is warped, file the surface flat.

20. Install the appropriate thermostat. (Figure 4) ____ ____

☑ **NOTE:** Always use a pellet type thermostat in a pressurized system. The bellows type will work only in a non-pressurized system. Check the thermostat to determine which side should be mounted toward the radiator and which side should be mounted toward the engine block. The thermostat may be stamped either way. Always follow the manufacturer's recommendations when selecting a thermostat.

21. Install a new gasket or seal the housing with RTV sealant. ____ ____

FIGURE 4 Yes No



Used with permission of Chrysler Corp.

☑ **NOTE:** Be sure to use the appropriate new seal and follow manufacturer's recommendations.

22. Carefully position the thermostat housing and install the bolts. ___ ___
23. Torque the bolts to specifications. ___ ___
24. Reconnect the radiator hose. ___ ___
25. Refill the radiator with coolant. ___ ___
26. Make a pressure test. (Job Sheet 1) ___ ___
27. Check for leaks. ___ ___
28. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. ___ ___

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 4

SERVICING ENGINE COOLING SYSTEMS

Name ______________________________

OBJECTIVE 11

Inspect, test, and replace a fan and fan components.

INTRODUCTION

The engine cooling fan plays a major role in providing the desirable rate and volume of air flow through the radiator core. At one time all fans were driven by a belt from the crankshaft. Now most are driven by either an electric motor or a temperature-sensitive fan drive clutch. Since there are so many different makes and models available today, the procedures that follow are general and should be used as guidelines when servicing a vehicle's fan and fan components.

EQUIPMENT AND SUPPLIES

- Vehicle with an electric fan
- Vehicle with a thermo-clutch fan
- Appropriate service manuals
- Shop towel or piece of paper
- Digital voltmeter
- Test light
- Timing light
- Jumper wire
- Sheet of cardboard
- Appropriate replacement parts, as needed
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret graphics and symbols

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Inspect and replace a fan

⚠ **WARNING:** FANS CAN COME ON UNEXPECTEDLY and cause severe cuts. Electric fans may start at any time regardless or whether the ignition switch is on or off. DISCONNECT THE FAN RELAY OR THE BATTERY GROUND CABLE ON VEHICLES WITH ELECTRIC FANS TO KEEP THE FAN FROM STARTING WHILE YOU WORK IN THE ENGINE COMPARTMENT.

Yes No

1. Inspect the radiator fan shroud for cracks and missing fasteners. ____ ____
2. If the shroud is cracked or missing fasteners, repair or replace the parts as needed. ____ ____
3. Inspect the fan for bent, cracked, broken, or loose blades. ____ ____
4. If the blades are bent, cracked, or broken, replace them. ____ ____

☑ **NOTE:** Do not attempt to straighten badly bent fan blades. Do not weld or braze broken or cracked blades.

5. Tighten loose blades as necessary. ____ ____
6. Replace the fan following the service manual procedures. ____ ____
7. Inspect and test the fan using one of the following procedures. ____ ____
8. Use the appropriate service manual to help you repair or replace a defective fan. ____ ____

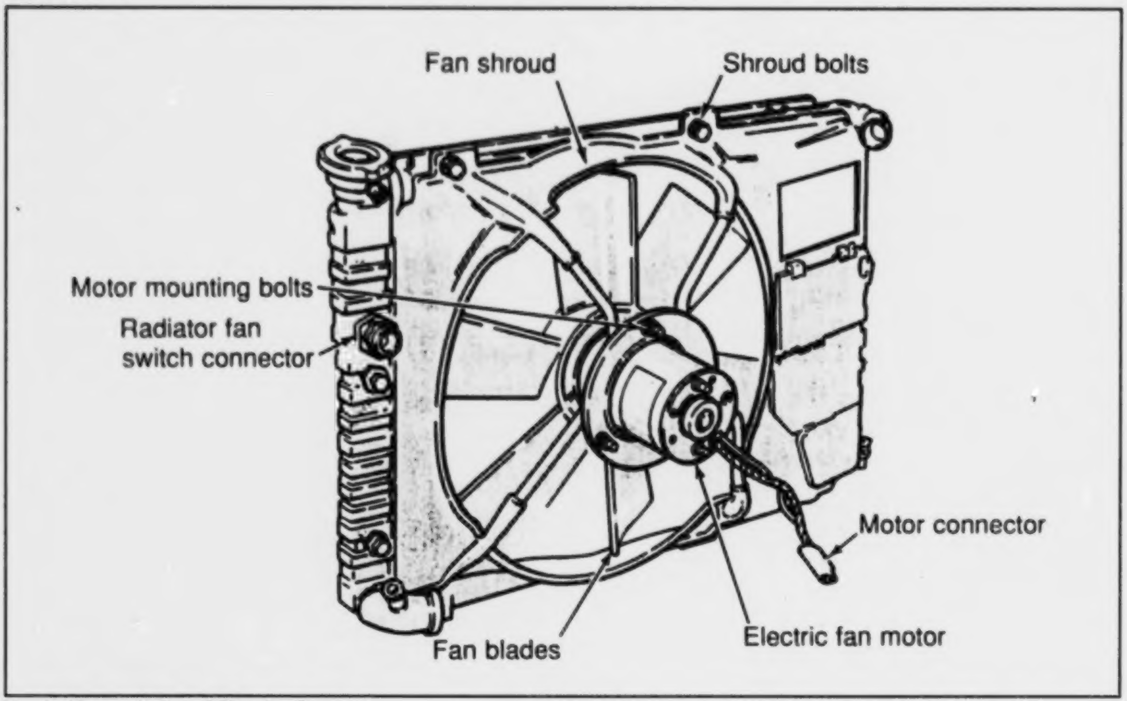
PROCEDURE

Job Acquisition/ Development
- Master specific job task/procedure

Inspect and test an electric fan

1. Inspect the fan for loose or broken wires and loose fan and motor mountings. (Figure 1) ____ ____

FIGURE 1


Fan shroud
Shroud bolts
Motor mounting bolts
Radiator fan switch connector
Motor connector
Fan blades
Electric fan motor

Used with permission of Chrysler Corp.

Yes No

2. If needed, repair or tighten the wires, fan and/or motor mountings. ____ ____

3. Allow the engine to idle until the fan comes on. ____ ____

   ☑ **NOTE:** Some vehicles will need to be driven before the fan comes on.

4. Hold a piece of paper or a shop towel to the front of the radiator to see if the fan is pulling enough air through the radiator core. ____ ____

   ☑ **NOTE:** The paper or towel should be held to the front of the radiator by the flow.

5. If the fan does not turn on, check the fuses to the fan. ____ ____

6. Check the fan's electrical connections to make sure they are not corroded or loose. ____ ____

Yes No

7. If either the fuses or the electrical connections are faulty, repair or replace them as needed. ____ ____

8. If the fuses and electrical connections are sound, supply voltage to the fan motor by connecting a jumper wire from the positive terminal of the battery to the fan power wire. (Figure 2) ____ ____

FIGURE 2

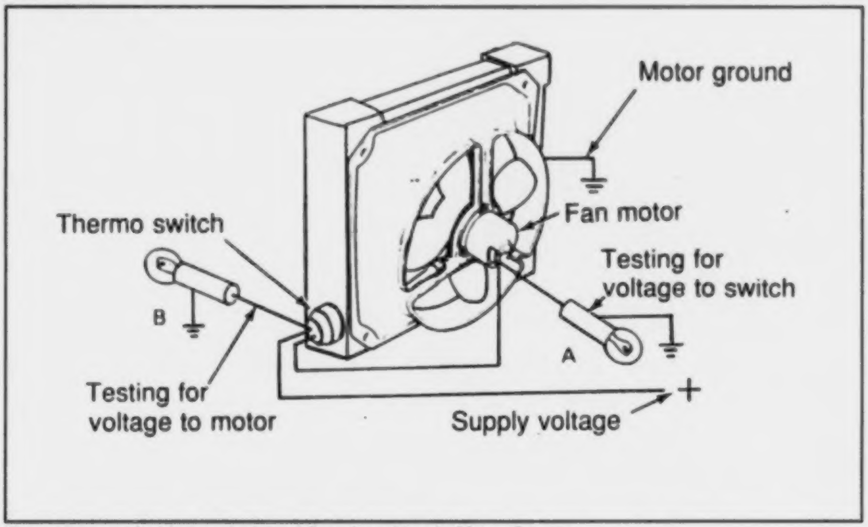

Motor ground
Fan motor
Thermo switch
Testing for voltage to switch
B
A
Testing for voltage to motor
Supply voltage
+

Illustration used with permission of American Honda Motor Co., Inc.

9. If the motor does not operate when you supply voltage, replace the motor. ____ ____

10. If the motor operates when you supply voltage, test the fan switch with either a digital voltmeter or a test light. ____ ____

☑ **NOTE:** Most electric cooling fans are controlled by a heat-sensitive switch located somewhere in the cooling system. Some of the more common locations are: the radiator, engine block, heater hose, or thermostat housing.

11. Use the service manual tests to check the fan motor circuit. ____ ____

	Yes	No
12. If the circuit does not pass these tests, it is faulty.	____	____
13. If necessary, replace the fan switch.	____	____
☑ **NOTE:** Use the manufacturer's recommended procedure to replace the fan switch.		

PROCEDURE

Job Acquisition/ Development
- Master specific job task/procedure

Inspect and test a thermo-clutch fan

	Yes	No
1. Inspect the thermo-clutch fan for fluid leakage.	____	____
2. If you find silicone oil leakage, replace the fan.	____	____
3. Push and pull the fan blades in and out on the shaft to check for endplay.	____	____
4. If there is any endplay, replace the fan clutch.	____	____
5. With the engine off, rotate the fan blade by hand and check the amount of resistance.	____	____
6. If there is a slight amount of resistance, the clutch is operating normally.	____	____
7. If the clutch is immovable (locked) regardless or whether the engine is hot or cold, it is defective and must be replaced.	____	____
8. If there is no resistance or high resistance, the clutch must be checked while the engine is running.	____	____
9. Start the engine.	____	____
10. If there is very little air being drawn through the radiator core while the engine is cool and running, the fan is operating properly.	____	____

☑ **NOTE:** Have your instructor demonstrate how to test for air flow.

Yes No

11. Block off the engine by placing a piece of cardboard or a fender cover on the outside of the radiator. ____ ____

☑ **NOTE:** This will help bring the engine to normal operating temperature quickly.

12. If there is a noticeable increase in the noise level of the fan as the engine warms up, the fan is operating properly. ____ ____

13. Notice when the fan engages as you watch the temperature gauge or temperature warning light. ____ ____

14. If the fan engages before the temperature gauge or warning light shows HOT, the fan is operating properly. ____ ____

15. Unblock the radiator and observe the fan as the engine begins to cool down. ____ ____

16. If the fan disengages as the engine cools down, it is functioning properly. ____ ____

17. Turn off the engine. ____ ____

18. If the fan turns a little but does not turn loosely and freely when the warm engine is shut down, the clutch is functioning properly. ____ ____

19. If the fan turns more than five turns, it is probably defective. ____ ____

20. If the clutch does not operate within the preceding guidelines, repair or replace it. ____ ____

21. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. ____ ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

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Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

OBJECTIVE SHEET

SERVICING EXHAUST SYSTEMS

4

INTRODUCTION

Although there are many systems on automobiles which are designed to reduce pollutants, the exhaust system has been the target of much change and legislation in attempts to keep the air clean and healthy. Untreated gases which escape from the exhaust system can cause serious illness and even death. Federal law prohibits any modifications of automotive emission systems without specific approval. Strict regulations affect both the driver of the automobile and the Engine Performance Technician whose responsibility is to keep the exhaust system components up to regulation standards.

PREREQUISITE

Unit 3, "Servicing Engine Cooling Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS	
PREREADING:	Read William F. Allman's article, "Good News About Noise," from *U.S. News & World Report*, September 9, 1991, pp. 59-60. As you read, consider how manufacturers have made the exhaust system not only more efficient, but quieter as well.
WRITING:	Write a short (one paragraph to one page) explanation of how manufacturers could make the exhaust systems of vehicles more efficient and what you think the reaction would be from consumers.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. Label the parts of an exhaust system indicated on an illustration.
2. Match the names of exhaust system components to descriptions of their functions.
3. Perform a backpressure test on an exhaust system. (Job Sheet 1)
4. Inspect, service, and replace exhaust system components located in the engine compartment. (Job Sheet 2)
5. Inspect, service, and replace exhaust system components located outside the engine compartment. (Job Sheet 3)
6. Describe the operation of a catalytic converter.
7. Name types of catalytic converters shown in illustrations.
8. Match the names of versions of catalytic converters to descriptions or explanations of their operation.
9. Inspect, test, service, and replace the catalytic converter of an exhaust system. (Job Sheet 4)

INFORMATION SHEET

SERVICING EXHAUST SYSTEMS

4

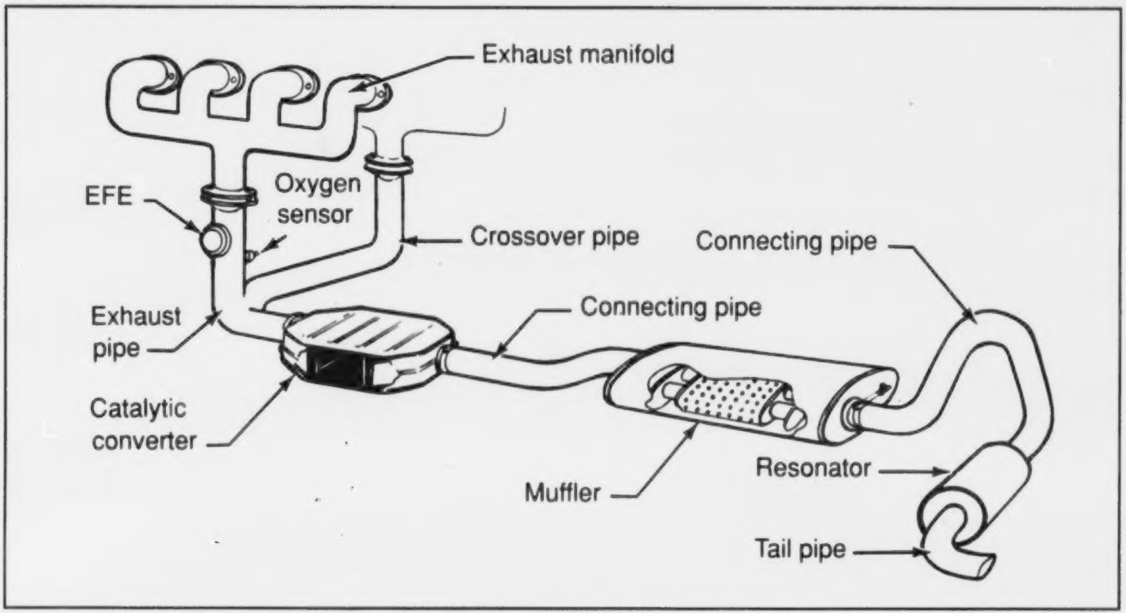
OBJECTIVE 1

Required Activities/
Resources
- Vehicle

Label the parts of an exhaust system indicated on an illustration.

Watch as your instructor points out the parts of an exhaust system on an actual vehicle.

FIGURE 1


Exhaust manifold
EFE
Oxygen sensor
Crossover pipe
Connecting pipe
Exhaust pipe
Connecting pipe
Catalytic converter
Muffler
Resonator
Tail pipe

OBJECTIVE 2

Required Activities/
Resources
- Transparency Master 1

Match the names of exhaust system components to descriptions of their functions.

Look at transparency 1 as your instructor explains the function of each component of the exhaust system.

WORDS YOU SHOULD KNOW	
baffle	design feature which controls the flow of liquids or gases
undercarriage	the supporting frame of a vehicle

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- **catalytic converter** — chemically changes harmful combustion gases into harmless byproducts

  ☑ **NOTE:** To aid in the fight against air pollution, catalytic converters have been installed in vehicles since 1975. A vehicle with a catalytic converter must use unleaded fuel only.

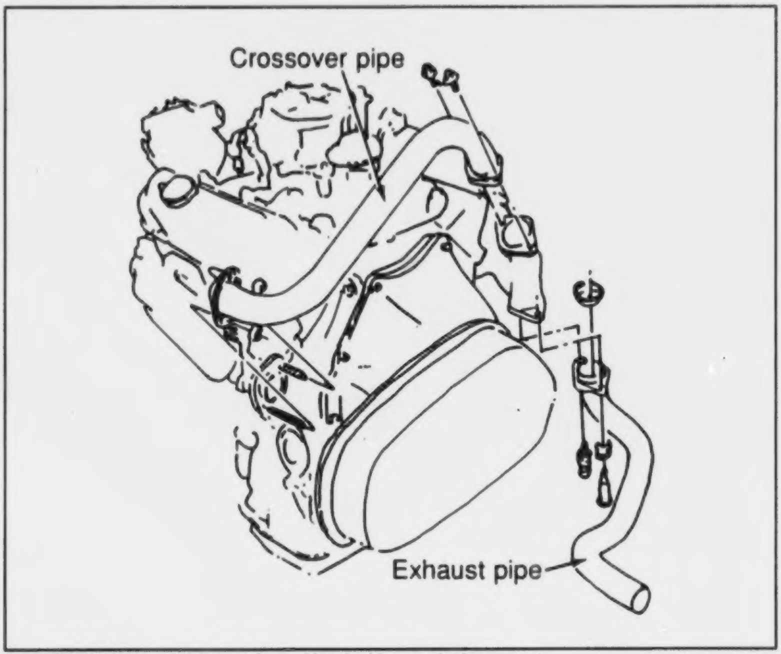
- **connecting pipes** — join exhaust system components downstream from the catalytic converter

  ☑ **NOTE:** Sometimes called *intermediate pipes*, connecting pipes are designed to channel the exhaust gases around components such as fuel tanks and shock absorbers in the vehicle's undercarriage.

- **crossover pipe** — connects both sides of the manifold on a V-type engine to allow them to share a common exhaust system (Figure 2)

EXAMPLE:

FIGURE 2



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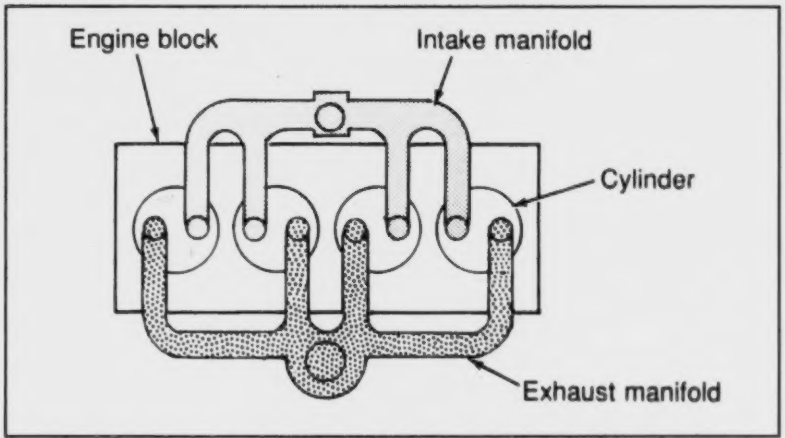
- **early fuel evaporation (EFE) system** — heats the air and fuel entering the intake manifold to help start a cold engine

☑ **NOTE:** An early type of EFE system, called *manifold heat controls* or *heat risers*, operated mechanically rather than by computer control. This old type of system is no longer produced, although these terms are sometimes applied to modern EFE systems.

- **exhaust manifold** — collects waste gases from each engine cylinder and directs them away from cylinder head exhaust ports (Figure 3)

EXAMPLE:

FIGURE 3



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☑ **NOTE:** The exhaust manifold is usually made of cast iron for durability.

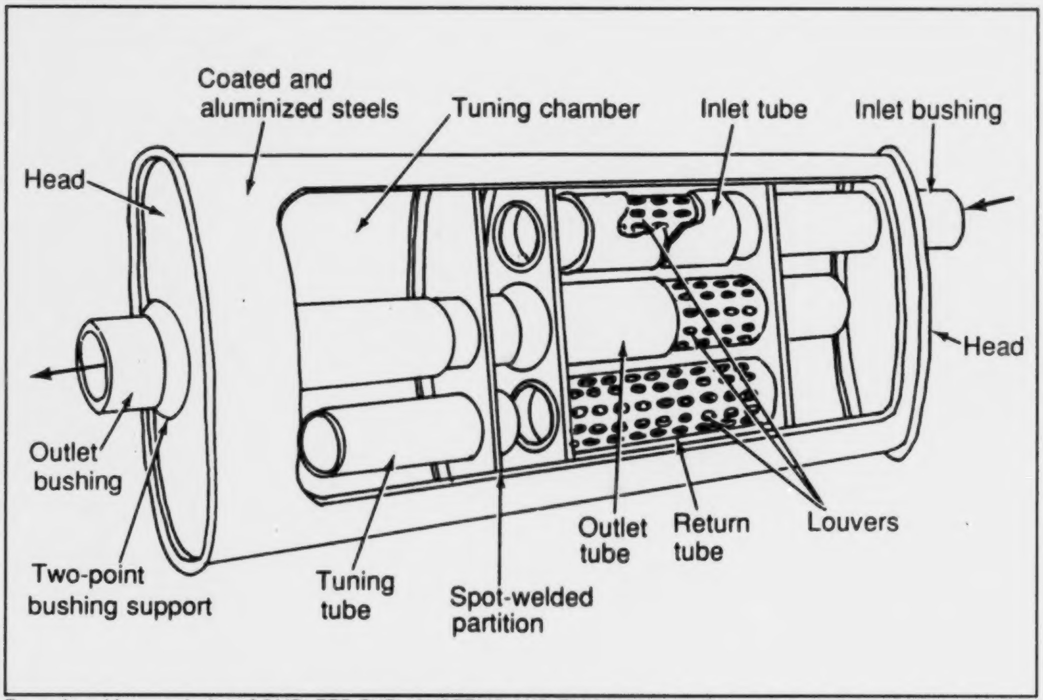
- **exhaust pipe** — directs exhaust gases from the exhaust manifold to the catalytic converter

- **muffler** — reduces noise produced by pulsating exhaust gases (Figure 4)

☑ **NOTE:** Much of the energy and noise of the exhaust flow is absorbed by chambers, baffles, tubes, and holes in the muffler. On an *electronic muffler*, sensors and microphones pick up the pattern of the engine pressure waves coming from the vehicle's exhaust pipe. This data is analyzed by a computer which instantly produces a mirror image pattern of pulses and sends it to speakers mounted near the exhaust outlet. These contrawaves cancel out the noise of the muffler.

EXAMPLE:

FIGURE 4


Coated and aluminized steels
Tuning chamber
Inlet tube
Inlet bushing
Head
Head
Outlet bushing
Two-point bushing support
Tuning tube
Spot-welded partition
Outlet tube
Return tube
Louvers

Reproduced by permission. COMPLETE FUEL SYSTEMS AND EMISSIONS, by Robert Scharff; Delmar Publishers, Inc.; Albany, NY; Copyright 1989; ISBN: 0-8273-3576-8.

- **oxygen sensor** – measures the amount of oxygen in the exhaust gas
- **resonator** — a small additional muffler sometimes added to absorb remaining exhaust sounds

  ☑ **NOTE:** Not all vehicles have resonators. Because of the need to reduce weight and cost, they are usually found on large vehicles.

- **tail pipe** — the end of the exhaust system from which gases pass to the outside air

OBJECTIVE 3 **Complete Job Sheet 1.**

OBJECTIVE 4 **Complete Job Sheet 2.**

OBJECTIVE 5 **Complete Job Sheet 3.**

OBJECTIVE 6

Required Activities/
Resources
- Explanation

Describe the operation of a catalytic converter.

Listen as your instructor explains how a catalytic converter operates.

WORDS YOU SHOULD KNOW

catalyst	any substance serving as the agent bringing about or hastening a result
emission	something emitted or discharged
pollutant	a harmful chemical or waste material discharged into the water or atmosphere

A catalytic converter intercepts harmful pollutants in engine exhaust and changes them into harmless ones through the use of a catalyst. Inside the catalytic converter, a catalyst (commonly platinum, palladium, or rhodium) thinly coats a ceramic surface designed to expose the exhaust to as much catalyst as possible. As the exhaust flows through the catalytic converter, the catalyst causes the chemicals in the pollutants to change into harmless gases. The exhaust gases leaving the catalytic converter have a much lower concentration of pollutants than they did when they came in.

OBJECTIVE 7

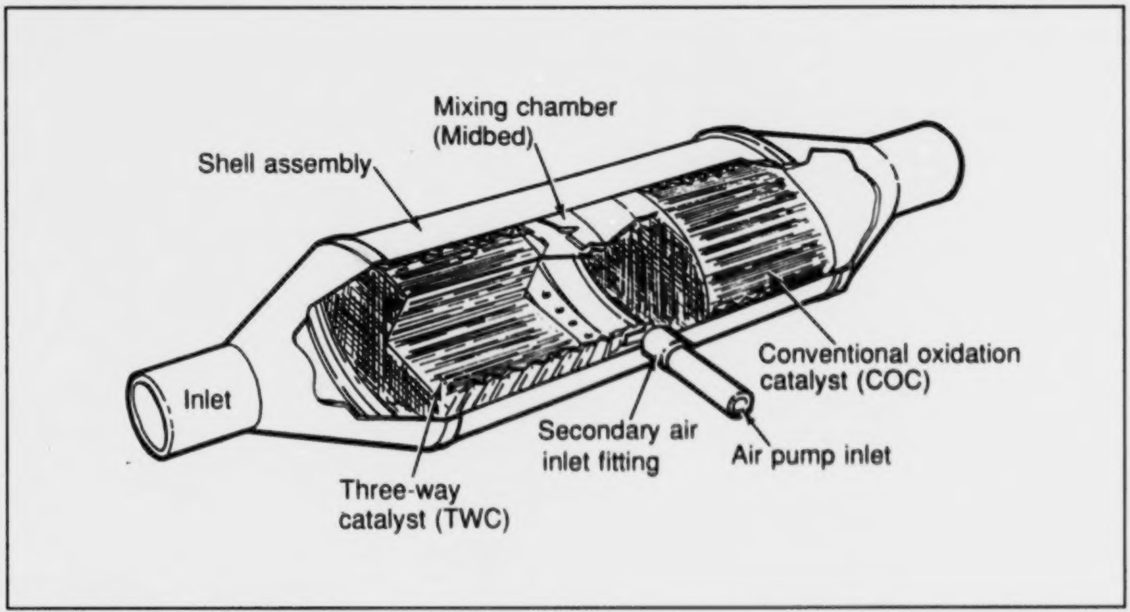
Required Activities/
Resources
- Transparency Master 2

Name types of catalytic converters shown in illustrations.

Look at transparency 2 as your instructor identifies the two types of catalytic converters and explains how the two types of catalytic converters differ.

- **Honeycomb Type**

FIGURE 5

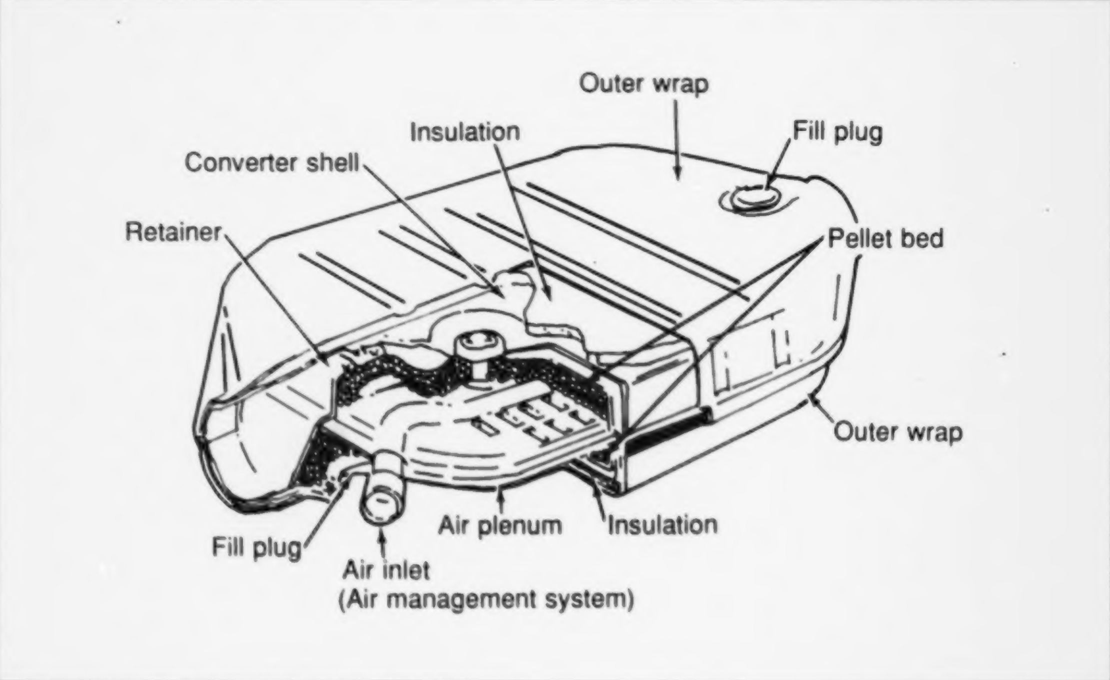

Mixing chamber (Midbed)
Shell assembly
Conventional oxidation catalyst (COC)
Inlet
Secondary air inlet fitting
Air pump inlet
Three-way catalyst (TWC)

Used with permission of Ford Motor Co.

☑ **NOTE:** The ***honeycomb type*** catalytic converter is the most common type. In it, the catalyst coats a ceramic surface shaped like a honeycomb. For effective operation, the exhaust gases must come in contact with as much catalyst as possible, and the honeycomb design promotes this maximum exposure.

- **Pellet Type**

FIGURE 6


Outer wrap
Insulation
Fill plug
Converter shell
Retainer
Pellet bed
Outer wrap
Air plenum
Insulation
Fill plug
Air inlet
(Air management system)

Copyright © General Motors Corp. Used with permission.

☑ **NOTE:** In a ***pellet type*** catalytic converter, the catalyst coats a number of small ceramic pellets. Like the honeycomb type, the pellet design promotes a maximum exposure of exhaust gases to the catalyst. Unlike the honeycomb type, the pellets can be removed and replaced, eliminating the need to replace the entire catalytic converter.

OBJECTIVE 8

Match the names of versions of catalytic converters to descriptions or explanations of their operation.

Required Activities/
Resources
– Explanation

? Listen as your instructor explains the operation of the different versions of catalytic converters.

WORDS YOU SHOULD KNOW

carbon dioxide	a colorless, odorless, incombustible gas
carbon monoxide	a colorless, odorless, highly poisonous gas
combustion	the act or process of burning
hydrocarbon	any compound containing only hydrogen and carbon
oxidize	to unite with oxygen, as in burning or rusting

Types of Catalytic Converters	Description/Operation
minicatalytic	A small honeycomb-type catalytic converter which may be built into or directly next to the exhaust manifold ☑ **NOTE:** Minicatalytic converters are used to save space, but are expensive and not very common.
two-way	Oxidizes harmful hydrocarbons and carbon monoxide, changing them into relatively harmless carbon dioxide and water
three-way	Oxidizes hydrocarbons and carbon monoxide and also reduces the damaging oxides of nitrogen, changing them to nitrogen and oxygen ☑ **NOTE:** Nitrogen is formed as a result of high combustion temperatures in the engine. Recently, controlled exhaust gas recirculation systems (EGRs) have been improved to control high combustion temperatures, and the production of nitrogen has been reduced.
single-bed	Has all the catalytic materials in one chamber ☑ **NOTE:** Two-way converters are always single-bed.
dual-bed	Has two chambers which reduce the nitrogen and oxidize the hydrocarbons and carbon monoxide ☑ **NOTE:** Three-way converters can be either single-bed or dual-bed.

OBJECTIVE 9 **Complete Job Sheet 4.**

SERVICING EXHAUST SYSTEMS

Name ____________________

OBJECTIVE 3

Perform a backpressure test on an exhaust system.

Required Activities/
Resources
– Explanation

Listen as your instructor explains what exhaust problems can cause low backpressure.

INTRODUCTION

Exhaust gases leaving the combustion chamber of the engine exert a pressure in the exhaust system called *backpressure*. A certain amount of backpressure is present in any exhaust system. However when backpressure exceeds acceptable limits, it causes the dilution of the incoming air-fuel mixture necessary for combustion. This leads to power loss, poor fuel economy, excessive blow-by, and increased engine wear. An engine with high backpressure will frequently falter and lose power under heavy acceleration then regain power when acceleration is eased.

Although excessive backpressure can be caused by other factors, it is usually caused by a blockage in the exhaust system. This blockage reduces the outward flow of exhaust gases. The blockage might be caused by problems like kinks in the exhaust pipe, a failed catalytic converter (the most frequent cause), or a collapsed muffler. It is critical that backpressure be kept within acceptable limits.

Whenever the symptoms of power loss, poor fuel economy, excessive blow-by, or noise indicating possible engine damage occur, the exhaust backpressure should be evaluated.

A vacuum gauge is the easiest and most available instrument to use for making a backpressure test, but if a vacuum gauge is not available, you can use a backpressure gauge. If you use a backpressure gauge, use the following procedure.

1. Remove the oxygen sensor and install a backpressure tester (a low-reading pressure gauge).

2. With the engine at normal operating temperature and running at 2500 rpm, read the backpressure on the gauge.

   ☑ **NOTE:** On some cars, a reading that exceeds 1.25 psi indicates a restricted exhaust system. Other engines may have a higher allowable backpressure.

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3. Follow the specifications in the appropriate vehicle service manual.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Hoist
- Remote starter switch
- Vacuum gauge or backpressure gauge
- Tachometer (with manual) appropriate for the vehicle
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Use content area vocabulary
- Interpret abbreviations/acronyms

Math Application
- Use English and metric measures

Data Analysis and Display
- Collect/record data

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Yes No

1. Raise the hood. ____ ____
2. Remove an intake manifold port vacuum line from the intake manifold. ____ ____

☑ **NOTE:** Have your instructor point out a manifold port vacuum line if you do not know where it is.

3. Connect a vacuum gauge between the vacuum line and the intake manifold port. ____ ____

☑ **NOTE:** If your shop has a backpressure gauge, ask your instructor how to use it.

4. If necessary, connect a tachometer. ____ ____

☑ **NOTE:** A tachometer measures the revolutions per minute (rpm) of an engine. Not all tachometers can be used on all vehicles.

5. Disconnect the vacuum hose from the EGR valve and plug it. ____ ____
6. Set the transmission in neutral or park. ____ ____
7. Start the engine and let it idle until it reaches normal operating temperature. ____ ____

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

8. Read and record the vacuum gauge measurement. ____ ____

9. Gradually increase the engine speed to 2000 rpm. ____ ____

10. Read and record the vacuum gauge measurement. ____ ____

11. If the vacuum gauge does not drop, or drops less than 2 inches from the reading made when the engine was idling, the exhaust system is not blocked, and you do not need to test further. ____ ____

12. If the vacuum gauge drops more than 2 inches from the reading made when the engine was idling, it is an indication that there is either an engine problem or a blockage in the exhaust system. Proceed with this backpressure test. ____ ____

13. If the reading drops more than 2 inches, turn off the engine. ____ ____

14. Raise the vehicle on a hoist if necessary to gain access to the exhaust manifold connection. ____ ____

15. Separate the exhaust pipe from the exhaust manifold downstream from the EFE system. ____ ____

⚠ **CAUTION:** EXHAUST COMPONENTS on a vehicle that has been running are hot. USE CAUTION WHEN WORKING AROUND EXHAUST COMPONENTS ON A VEHICLE THAT HAS BEEN RUNNING.

---

16. Start the engine and gradually increase the speed to 2000 rpm. ____ ____

17. With your face at least 18 inches away from the exhaust manifold, observe the operation of the EFE. ____ ____

⚠ **CAUTION:** EXHAUST COMING FROM THE EXHAUST MANIFOLD is hot. DO NOT GET TOO CLOSE TO THIS EXHAUST SOURCE OR YOU WILL RECEIVE SEVERE BURNS.

Yes No

18. If the arm on the EFE moves freely when the exhaust gases come out, the EFE is working correctly. ____ ____

    ☑ **NOTE:** If the EFE arm does not move when the exhaust gases come out, the blockage may be in the EFE system. Stop the engine and dismantle and check the EFE system. Replace a faulty EFE system before continuing.

19. Read the vacuum gauge. ____ ____

20. If the gauge reading has still dropped more than 2 inches from the reading made while the engine was idling, there is an engine problem and engine tests should be made to determine the difficulty. ____ ____

    ☑ **NOTE:** After the engine is repaired, another backpressure test can be made to determine if the vehicle has an exhaust block as well as an engine problem.

21. If the gauge reading does not drop or drops less than 2 inches, there is a blockage in the exhaust system and the exhaust system backpressure test should be continued to locate its source. ____ ____

    ☑ **NOTE:** At this point, many automotive shops will send the vehicle to a muffler shop. The muffler shop will make a complete backpressure test and identify the exhaust component causing the blockage. A complete backpressure test requires that individual exhaust components be systematically disconnected and then reconnected, a procedure that often requires rewelding. This rewelding frequently cannot be done in automotive classes. Check with your instructor before proceeding with the rest of the backpressure test.

22. Turn off the engine. ____ ____

23. Reconnect the exhaust manifold to the exhaust pipe. ____ ____

24. If you will not be continuing to make a complete backpressure test, stop here, clean your work area, and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. ____ ____

	Yes	No
25. If you are continuing the backpressure test, disconnect the connecting pipe from the catalytic converter downstream from the catalytic converter.	____	____
26. Start the engine, gradually increase speed to 2000 rpm, and read the vacuum gauge.	____	____
27. If the reading does not drop, or drops less than 2 inches, the blockage is in an exhaust component further downstream. Continue with this procedure.	____	____
☑ **NOTE:** If the reading drops more than 2 inches, there is a blockage in the catalytic converter and the converter should be replaced before continuing.		
28. If the reading does not drop more than 2 inches, reconnect the catalytic converter and disconnect the connecting pipe downstream of the muffler.	____	____
29. Start the engine, increase speed to 2000 rpm, and read the vacuum gauge.	____	____
30. If the reading does not drop, or drops less than 2 inches, the blockage is in an exhaust component further downstream. Continue with this procedure.	____	____
☑ **NOTE:** If the reading drops more than 2 inches, the muffler is blocked and should be replaced before continuing.		
31. If the reading does not drop, or drops less than 2 inches, reconnect the muffler and disconnect the connecting pipe downstream from the resonator.	____	____
32. Start the engine, increase speed to 2000 rpm, and read the vacuum gauge.	____	____
33. If the reading does not drop, or drops less than 2 inches, the blockage is in the tail pipe. Continue with this procedure.	____	____

	Yes	No
☑ **NOTE:** If the reading drops more than 2 inches, the resonator is blocked and should be replaced before continuing.		
34. If the reading did not drop, or dropped less than 2 inches, check the tail pipe for obstruction. Replace it if necessary.	____	____
35. If the blockage was not found, repeat this Job Sheet and check your results.	____	____
36. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1

Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 2

SERVICING EXHAUST SYSTEMS

Name ____

OBJECTIVE 4

Inspect, service, and replace exhaust system components located in the engine compartment.

Required Activities/
Resources
– Explanation

Listen as your instructor explains the relationship between exhaust system components.

INTRODUCTION

The exhaust manifold and the early fuel evaporation (EFE) valve are located within the engine compartment. Exposure to high temperatures is the biggest enemy of the exhaust manifold. Excessive heat causes warping or cracking. Be sure the manifold is cool before attempting to remove it. This will reduce the chance of warping the manifold or breaking the assembly bolts.

Noise from the area of the exhaust manifold will indicate that you may need to inspect, service, or replace the exhaust manifold and/or the EFE valve. When replacing either component, be sure to use original parts or parts which are designed for the vehicle. By using compatible parts, you will help ensure correct alignment with other exhaust system components and control exhaust noise.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Hoist
- Torque wrench
- Squirt can of engine oil
- Graphite oil
- Gasket remover
- Wire brush
- Scraper
- High temperature antiseize lubricant
- New exhaust manifold gasket, if needed
- New exhaust pipe gasket (donut), if needed
- Penetrating oil
- Ball-peen hammer

- Feeler gauge
- Straightedge
- Torque wrench
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret graphics and symbols
- Use content area vocabulary
- Interpret abbreviations/acronyms

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Inspect for leaks Yes No

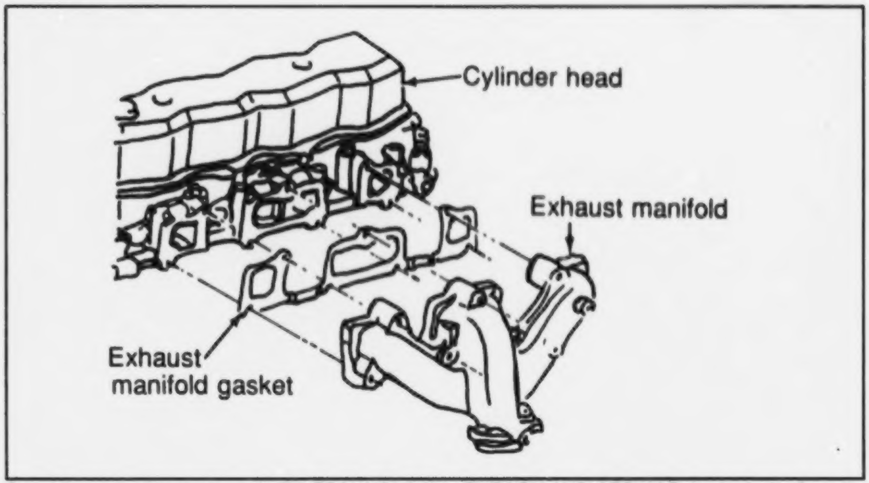
1. Raise the hood. ____ ____
2. Remove the battery ground to avoid short-circuiting the electrical system. ____ ____

   ☑ **NOTE:** The battery ground is the battery cable connecting the negative (-) post of the battery to the body of the vehicle.

3. Raise the vehicle on a hoist if necessary to obtain access to the exhaust pipe and/or exhaust manifold. ____ ____
4. Check the exhaust manifold and exhaust pipe connections for loose or missing bolts. ____ ____
5. If any bolts are missing or loose, replace them and torque all bolts to specifications using the tightening sequence recommended in the service manual. ____ ____
6. Squirt a small amount of engine oil onto the sealing areas between the exhaust manifold and the cylinder head and between the exhaust manifold and the exhaust pipe. (Figure 1) ____ ____

   ☑ **NOTE:** These are the most common points of leakage.

FIGURE 1



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Yes No

7. Start the engine. ____ ____

8. Watch for bubbles appearing at the sealing surfaces between the exhaust manifold and the cylinder head and/or between the exhaust manifold and the exhaust pipe. Bubbles indicate that the seal at this location is leaking. ____ ____

9. Note the position of any leaks. ____ ____

PROCEDURE

Inspect and service the EFE valve and exhaust pipe

1. If the connection between the exhaust manifold and the exhaust pipe is leaking, you will need to replace the exhaust gasket (donut) between these parts. ____ ____

☑ **NOTE:** Some vehicles, particularly domestic vehicles, do not use engine gaskets as original equipment.

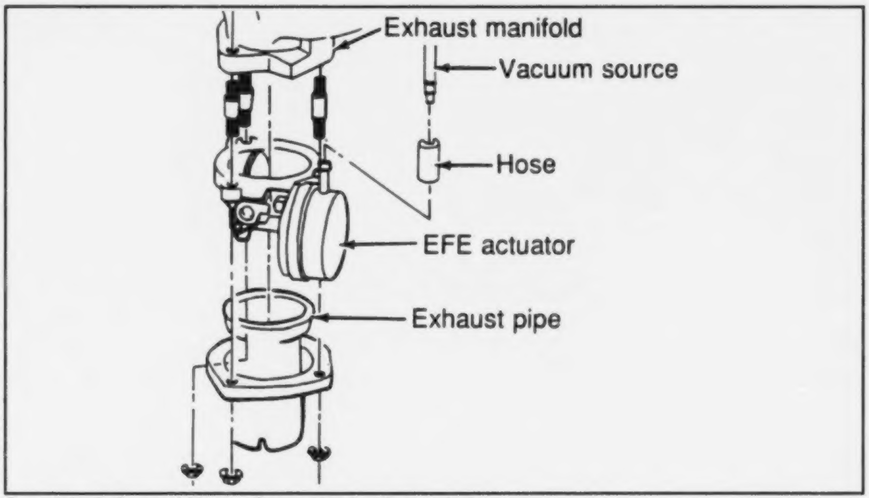
Yes No

2. Separate the exhaust pipe from the exhaust manifold. ____ ____

☑ **NOTE:** If exhaust system nuts and bolts do not unscrew easily, use penetrating oil to loosen them. Tap the fasteners with a ball-peen hammer to allow the solvent to penetrate. The fasteners should be loosened in a few minutes.

3. Carefully remove the EFE valve. ____ ____

FIGURE 2



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4. Spray the valve liberally with graphite oil. ____ ____

5. Using pliers, work the shaft and counterweight slowly back and forth until the shaft moves freely. ____ ____

6. Follow the instructions in the manufacturer's service manual to test the operation of the EFE valve. ____ ____

7. Clean the sealing surfaces of the exhaust pipe and exhaust manifold with a scraper, a wire brush, and gasket remover, being sure to remove all remaining particles of old gasket and sealer. ____ ____

Yes No

⚠ **NOTICE:** USING A WIRE BRUSH OR A METAL SCRAPER on an aluminum manifold will scratch it. DO NOT USE A WIRE BRUSH OR A METAL SCRAPER IF THE MANIFOLD IS ALUMINUM.

---

8. Install a new exhaust pipe gasket (donut). ____ ____
9. Replace the EFE valve on the lower end of the exhaust manifold. ____ ____
10. Reconnect the exhaust pipe to the EFE valve, torquing the studs or bolts to specifications. ____ ____
11. If you do not need to inspect and service the exhaust manifold, skip to steps 14 and 15 of the next procedure. ____ ____

PROCEDURE

Inspect and service the exhaust manifold

☑ **NOTE:** This procedure should be done if the sealing area between the exhaust manifold and the cylinder head is leaking.

1. Disconnect the brackets and hangers holding the exhaust manifold in place. ____ ____
2. Remove the exhaust manifold from the cylinder head, using the manufacturer's torque sequence in reverse to loosen each bolt. ____ ____
3. Remove the bolts in the same reverse sequence. ____ ____
4. Remove the exhaust manifold. ____ ____
5. Inspect the exhaust manifold for cracks. If the manifold is cracked, it must be replaced. ____ ____
6. Clean the sealing surface of the exhaust manifold and the cylinder head with a scraper, a wire brush, and gasket remover, being sure to remove all remaining particles of old gasket and sealer. ____ ____

Yes No

⚠ **NOTICE:** USING A WIRE BRUSH OR A METAL SCRAPER on an aluminum manifold will scratch it. DO NOT USE A WIRE BRUSH OR A METAL SCRAPER IF THE MANIFOLD IS ALUMINUM.

---

7. Inspect the sealing surface of the exhaust manifold for dents, cracks, or gouges which might prevent effective sealing. Replace the manifold if any are found. ____ ____

8. Use a straightedge and a feeler gauge to check the sealing surface of the exhaust manifold to see if it is warped. ____ ____

   ☑ **NOTE:** Check the service manual for the amount of variance allowed from perfect flatness. If no variance is listed, use .002 inches. If the surface exceeds this variance, the exhaust manifold should be removed and sent to a machine shop to be surfaced.

9. Lubricate the threads of the cylinder head studs with high-temperature antiseize lubricant. ____ ____

10. Slide the new exhaust manifold gasket over the cylinder head studs. ____ ____

11. Align the prepared manifold sealing surface to the cylinder head. ____ ____

12. Install the bolts finger tight. ____ ____

13. Torque the bolts to specification using the tightening sequence recommended in the service manual. ____ ____

14. Reconnect the battery ground. ____ ____

15. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. ____ ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 3

SERVICING EXHAUST SYSTEMS

4

Name ______________________________

OBJECTIVE 5

Inspect, service, and replace exhaust system components located outside the engine compartment.

Optional Activities/
Resources in
Instructor's Guide

INTRODUCTION

The largest portion of the exhaust system is located outside the engine compartment. It is vitally important that these components function effectively for three reasons: (1) federal regulations mandate that exhaust emissions should be within certain limits, (2) passengers are in danger of inhaling toxic fumes if the system leaks, and (3) passenger comfort will be reduced if the heat and noise of exhaust gases is not directed away from the passenger compartment.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Lift or ramp to raise the vehicle
- Pencil and paper
- Remote starter switch
- New metal gaskets
- Scraper or wire brush
- Rubber mallet
- Torque wrench
- Muffler sealant
- Shop light
- Small hammer
- Chisel
- Basic hand tool set

NOTICE: PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

General Science
- Investigate/apply technology

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Inspect the exhaust system components Yes No

1. Raise the hood. ____ ____
2. Connect a remote starter switch to the engine. ____ ____

☑ **NOTE:** Remote starter switches connect to different vehicles different ways. If you don't know how to connect a remote starter switch to the vehicle you are working on, have your instructor show you how.

3. Raise the vehicle and support it safely. ____ ____
4. Use the remote starter switch to start the engine. ____ ____

⚠ **DANGER:** UNVENTED EXHAUST FUMES in a closed building can cause death. ALWAYS CONNECT THE VEHICLE'S EXHAUST TO A VENT HOSE WHEN YOU RUN AN ENGINE IN A CLOSED SHOP.

---

5. Allow the engine to run as you slowly follow the exhaust system from front to rear, listening for hissing or rumbling sounds which would indicate exhaust system failure. ____ ____
6. Turn off the engine and wait until the exhaust system has thoroughly cooled. ____ ____
7. Use a shop light to check the exhaust system for rust, road damage, holes, distended muffler seams, broken or missing hangers or clamps, or discoloration from carbon. ____ ____
8. Note any such damage. ____ ____
9. Move along the exhaust system from front to rear gently tapping exhaust system components with a rubber mallet. ____ ____

☑ **NOTE:** You should hear a solid ringing sound from good parts and a dull sound from rusted or worn-out parts.

10. Note any components that you suspect are rusted. ____ ____

Yes No

11. Attempt to move the exhaust assembly by hand. ____ ____

    ☑ **NOTE:** It should move only slightly.

12. If any component feels loose, check the clamps and hangers holding it and tighten them properly. ____ ____

13. Check for kinks or dents in any component. ____ ____

    ☑ **NOTE:** A kink or dent in the exhaust system can restrict the flow of exhaust gases, causing excessive backpressure and poor engine performance.

14. Replace any damaged parts. ____ ____

15. Inspect each connecting point in the system for carbon deposits or soot. ____ ____

    ☑ **NOTE:** Presence of carbon or soot indicates that exhaust gases are leaking.

16. If you find carbon or soot, check the connections between components for loose connecting bolts or broken gaskets. ____ ____

17. Tighten bolts and replace gaskets as needed. ____ ____

18. Check the catalytic converter for blue or brown discoloration on the outer shell or blistering of paint on parts adjacent to the converter. ____ ____

    ☑ **NOTE:** If such discoloration or blistering is present, the converter is probably overheating and needs to be replaced.

PROCEDURE

Job Acquisition/ Development

- Master specific job task/procedure

Service and replace exhaust system components outside the engine compartment

1. If there is a heat shield that protects the catalytic converter, remove it. ____ ____

2. Remove any fasteners and clamps that hold the catalytic converter in position. ____ ____

	Yes	No
3. Separate the catalytic converter from the exhaust pipe.	____	____
4. Refer to the vehicle's service manual for specifications to see if the catalytic converter needs to be replaced.	____	____
5. Replace the converter if necessary.	____	____
6. Use a scraper or wire brush to clean old gaskets from the sealing connecting surfaces.	____	____
7. Install new gaskets.	____	____
8. Reinstall the catalytic converter to the exhaust pipe.	____	____
9. Tighten the flange bolts finger tight.	____	____
10. Torque the bolts to specification.	____	____
11. Install the converter's lower heat shield, if equipped.	____	____
12. Tap on the muffler with a rubber mallet, listening for evidence the muffler is rusted.	____	____

☑ **NOTE:** Mufflers usually rust from the inside out. By tapping a rubber mallet on a rusted muffler, the sound of rust can be heard falling on the inside of the muffler. If the muffler is rusted, replace it.

	Yes	No
13. Loosen the clamps and hangers which hold the muffler, and pull the muffler away from the vehicle.	____	____
14. Use a hammer to tap the muffler free from the connecting pipe and/or tail pipe.	____	____

☑ **NOTE:** You may need to use a chisel or heat to help you disconnect the muffler from the connecting pipes. See your instructor if you have any trouble.

	Yes	No
15. Thoroughly coat the inlet and outlet bushings of the new muffler with muffler sealant.	____	____

Yes No

16. Coat the outside of tail pipe and the connecting pipe coming to the muffler with the same sealant. ____ ____

☑ **NOTE:** Muffler sealant not only forms a permanent seal but protects against sound and gas leaks.

17. Connect the muffler to the connecting pipe, making sure the connecting pipe fits at least 1½-2 inches into the muffler bushing. ____ ____

18. Make sure the muffler is properly aligned, and then tighten the front clamp snugly. ____ ____

19. Insert the tail pipe into the muffler, align it properly, and clamp it securely. ____ ____

20. Install the rear muffler hanger so it directly supports the muffler outlet. ____ ____

21. Make sure all parts of the system are correctly aligned and tightened. ____ ____

22. Make sure all parts of the exhaust system have adequate clearance from other parts of the vehicle. ____ ____

☑ **NOTE:** Heat can cause the system to expand by as much as 1 inch.

23. Start the engine and let the engine idle until the temperature gauge moves into the normal range. ____ ____

24. Listen for rattles from the exhaust system. ____ ____

25. Turn off the engine. ____ ____

26. With the system at normal operating temperature, retighten all connections and recheck the clearances. ____ ____

⚠ **CAUTION:** EXHAUST COMPONENTS on a vehicle that has been running are hot. USE CAUTION WHEN WORKING AROUND EXHAUST COMPONENTS ON A VEHICLE THAT HAS BEEN RUNNING.

	Yes	No
27. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

JOB
SHEET 4

SERVICING EXHAUST SYSTEMS

4

Name ____________________

OBJECTIVE 9

Required Activities/
Resources
- Explanation

Inspect, test, service, and replace the catalytic converter of an exhaust system.

Listen as your instructor explains why the catalytic converter must be in good condition for the exhaust system to perform correctly.

INTRODUCTION

The catalytic converter, a part of the exhaust system, converts harmful pollutants in exhaust gas into harmless gases. Vehicles with catalytic converters must use unleaded gasoline because lead in gasoline will coat the catalyst and make it ineffective. For the catalytic converter to be most effective, the air-fuel mixture used in the engine must be correct. Small variations in the air-fuel ratio can cause large increases in exhaust emissions.

The catalytic converter usually requires no service or maintenance other than using only unleaded gasoline. Under normal operation the catalytic converter should last the life of the vehicle; however, the converter may become damaged, ineffective, or clogged. Due to the cost involved and the difficulty in disposing of hazardous material, the catalyst in pellet-type catalytic converters is no longer replaced. The whole catalytic converter is replaced when necessary.

Guidelines:

- If the engine of the vehicle has been running, the catalytic converter may be hot. Allow the catalytic converter to cool before beginning your inspection. The catalytic converter requires a longer cooling-off period than the muffler.
- The catalytic converter is made of stainless steel, so it will not rust, but it may develop cracks and holes. This type of damage may cause noise in the system.

- Inspect the exhaust system for a dented or collapsed pipe that may cause additional backpressure which will affect the catalytic converter.

- Catalytic converters can overheat, causing a bluish or brownish discoloration of the outer stainless steel shell. Bulging or distortion usually indicates heat damage to the converter.

- Small pellet particles coming out of the tail pipe means the converter has overheated and the pellet support has warped. The catalytic converter must be replaced.

- A slight rotten egg smell coming from the catalytic converter is considered normal, but when a strong rotten egg smell is detected, it is usually due to sulfur in the gasoline. The catalytic converter combines the sulfur with hydrogen to produce hydrogen sulfide which produces the smell. Try a different brand of gasoline to solve this problem. A vehicle with too rich a fuel mixture may also cause this problem. Tuning the engine or checking and repairing the fuel delivery system may also be necessary.

- If the engine has low power, make a backpressure test to check for a clogged catalytic converter or a restricted exhaust system. (See Job Sheet 1.)

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by the procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Job Acquisition/ Development

- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

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EVALUATOR'S COMMENTS

OBJECTIVE SHEET

EVALUATING ENGINE CONDITION

5

INTRODUCTION

Today's engines are complex in nature, using advanced engine designs for improved power, efficiency, and dependability. A thorough understanding of engine operation is needed before engine problems can be evaluated, diagnosed, and corrected. A sincere desire to understand the mechanical and performance problems of a variety of engines will speed the learning process.

The Engine Performance Technician has to make accurate diagnoses, analyze failed parts, and work quickly with attention to detail. Some engines will need minor adjustments, while others will require complete disassembly. Determining the proper course of action will require the technician to use a variety of diagnostic instruments and tools. Learning the operation and evaluating readings of diagnostic tools is critical to becoming an effective Engine Performance Technician.

Keen observation and listening skills are necessary to evaluate engine conditions. When diagnosing engine problems, become a person of habit and follow a set pattern. When you discover the reason for a problem, make a mental note of it for future reference. If you diagnose problems in this manner, you will increase the likelihood of fixing them correctly the first time and become a valuable employee.

PREREQUISITE

Unit 4, "Servicing Exhaust Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS	
PREREADING:	Read Ken Freund's article,"What's in a Tune-Up?" from the November 1992 issue of *Trailer Life* magazine, pp. 58-67.
WRITING:	Write one or two paragraphs explaining the purpose of a tune-up.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. List the major steps that should be included in an engine tune-up.
2. Compare and contrast valve train timing and ignition timing.
3. Give reasons why proper valve train timing is important to correct engine operation.
4. Name types of valve trains shown in illustrations.
5. Match the names of valve train parts to descriptions of their functions.
6. List three ways the camshaft part of a valve train is driven.
7. Verify correct valve timing. (Job Sheet 1)
8. Adjust valves. (Job Sheet 2)
9. Perform cylinder compression tests. (Job Sheet 3)
10. Perform a cylinder leakage test. (Job Sheet 4)

11. Interpret cylinder compression test results. (Assignment Sheet 1)

12. State reasons why a vehicle may require use of high octane fuel.

13. List problems which may be created by using high octane fuel in a vehicle designed to use regular fuel.

14. List problems which may be created by using regular fuel in a vehicle designed to use high octane fuel.

15. List common engine performance problems.

16. List common causes of engine mechanical problems.

17. List common causes of engine lubrication problems.

18. List common causes of engine overheating.

19. List engine parts that are most frequently affected by normal engine wear and tear.

20. List the steps of engine inspection.

21. Inspect an engine assembly for leaks. (Job Sheet 5)

22. Match colors of exhaust to the condition or problem indicated by the color.

23. Describe an abnormal exhaust odor and the problem it indicates.

24. Diagnose the cause of unusual exhaust color, odor, and sound. (Assignment Sheet 2)

25. Perform engine vacuum tests. (Job Sheet 6)

26. Interpret vacuum gauge readings. (Assignment Sheet 3)

27. Perform a cylinder power balance test. (Job Sheet 7)

28. Calibrate an exhaust gas analyzer, test a vehicle's exhaust, and obtain exhaust gas readings. (Job Sheet 8)

29. Match the names of engine diagnostic tests to the engine conditions they evaluate.

30. Name types of engine test equipment shown in illustrations.

31. Match the names of engine test equipment to the information which can be obtained with that equipment.

32. List the steps in making a diagnostic road test.

33. Verify driver's complaint. (Assignment Sheet 4)

34. Diagnose the cause of unusual engine noise and vibration problems. (Assignment Sheet 5)

INFORMATION SHEET

EVALUATING ENGINE CONDITION

5

OBJECTIVE 1

List the major steps that should be included in an engine tune-up.

- Replace the spark plugs.
- Inspect the distributor, including points and condenser replacement or electronic distributor maintenance.
- Check and adjust the ignition timing.
- Replace the air and fuel filters.
- Adjust the fuel system.
- Test the emission control system and service.
- Perform a general inspection.
- Take the vehicle for a road test.

☑ **NOTE:** The traditional concept of a tune-up was based on periodic or preventive maintenance. The modern concept of a tune-up is based on testing, diagnosis, and correction, along with those few periodic services that remain.

OBJECTIVE 2

Required Activities/
Resources
– Explanation

Compare and contrast valve train timing and ignition timing.

Listen to your instructor's explanation of how valve train timing and ignition timing differ and how they are similar.

	Valve Train Timing	Ignition Timing
Valve opens in relation to piston position.	X	
Spark plugs fire in relation to the position of the engine pistons.		X
Mechanically controlled	X	X
Electronically controlled	X	X
Faulty timing may cause the engine to run rough	X	X
Critical to effective emission control	X	X

OBJECTIVE 3

Required Activities/
Resources
- Explanation

Give reasons why proper valve train timing is important to correct engine operation.

Listen to your instructor explain how improper valve train timing can affect emissions.

- To increase engine power
- To increase fuel economy
- To decrease pollutants

OBJECTIVE 4

Required Activities/
Resources
- Transparency Masters 1 and 2
- Engine with overhead valve train
- Engine with overhead cam valve train

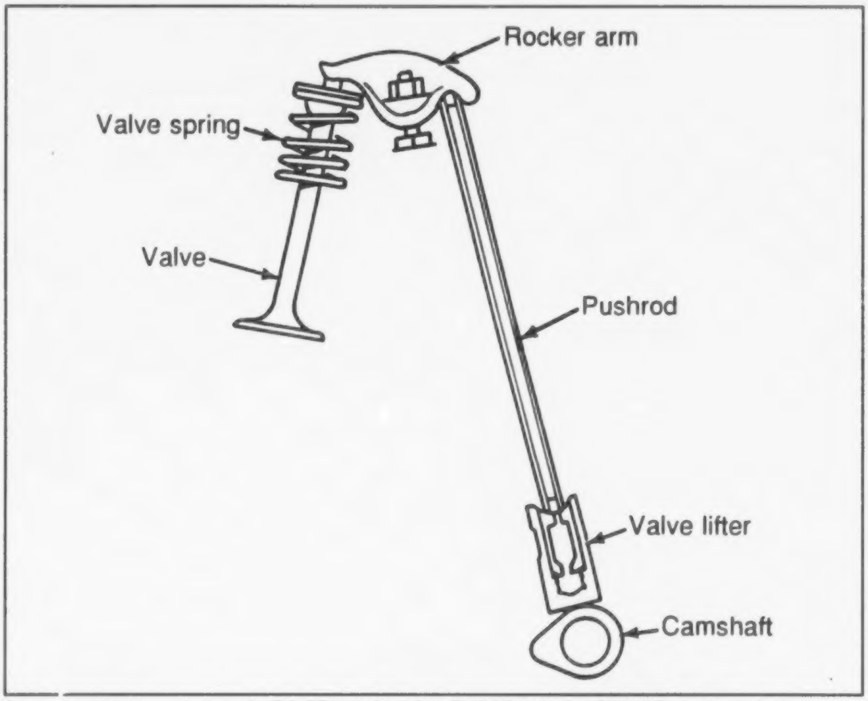
Name types of valve trains shown in illustrations.

Look at transparencies 1 and 2 as your instructor explains the differences between the two types of valve trains.

Look at an actual engine with an overhead valve train and one with an overhead cam valve train.

- **overhead valve**

FIGURE 1



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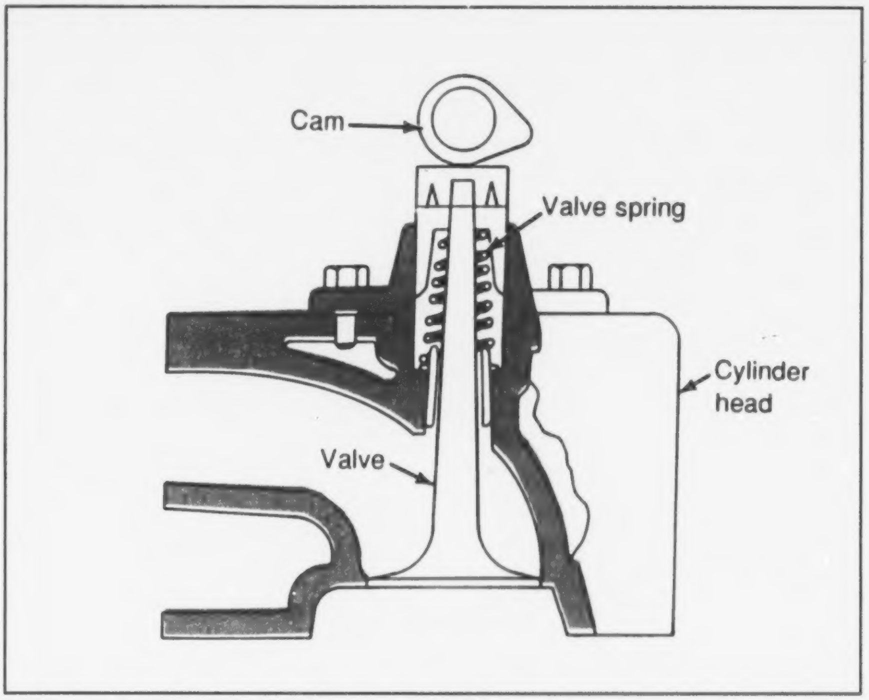
- **overhead cam**

FIGURE 2



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OBJECTIVE 5

Required Activities/ Resources
– Transparency Masters 1 and 2

Match the names of valve train parts to descriptions of their functions.

Look at transparencies 1 and 2 as your instructor describes the functions of the parts of valve trains.

- **cylinder head** — closes off the top of the cylinders and contains the valves and the parts through which the flow of the air-fuel mixture is regulated

  NOTE: The cylinder head bolts to the block deck to enclose the top of the cylinder.

- **camshaft** — operates the valve train

  NOTE: The lobes on the camshaft control the opening and closing of the valves.

- **valve** — controls the flow of the air-fuel mixture into and out of the engine cylinder
- **valve spring** — keeps the valve in the normally closed position
- **valve lifter** — transfers motion from the cam to the pushrod

  ☑ **NOTE:** Valve lifters, sometimes called *tappets*, ride against the cam lobes. The valve lifters are located in the block or cylinder head. They fit into machined holes, termed *lifter bores*. When the cam lobe turns into the valve lifter, the valve lifter is pushed up in its bore. This pushes on the pushrod and transfers pressure to the rocker arm to open the valve. When the lobe rotates away from the lifter, the lifter is pushed down in its bore by the action of the valve spring. The keeps the lifter in constant contact with the camshaft.

- **pushrod** — transfers motion between the valve lifter and the rocker arm
- **rocker arm** — transfers motion from the pushrod to the valve

  ☑ **NOTE:** Rocker arms can be found on both overhead cam and overhead valve engines. Various methods are used to support the rocker arm on the cylinder head: rocker shaft, rocker stud, or rocker pedestal. Rocker arms are both nonadjustable and adjustable.

OBJECTIVE 6

Required Activities/
Resources
– Explanation

List three ways the camshaft part of a valve train is driven.

Listen as your instructor explains the advantages and disadvantages of the three ways the camshaft can be driven.

- belt
- chain
- gear set

OBJECTIVE 7

Complete Job Sheet 1.

OBJECTIVE 8

Complete Job Sheet 2.

OBJECTIVE 9

Complete Job Sheet 3.

OBJECTIVE 10

Complete Job Sheet 4.

OBJECTIVE 11

Complete Assignment Sheet 1.

OBJECTIVE 12

State reasons why a vehicle may require use of high octane fuel.

Required Activities/
Resources
– Explanation

Optional Activities/
Resources in
Instructor's Guide

(?) Listen as your instructor explains high compression engines and why they may require high octane fuel.

- The vehicle has a high compression engine.
- The vehicle uses a turbocharger or supercharger.

OBJECTIVE 13

List problems which may be created by using high octane fuel in a vehicle designed to use regular fuel.

- engine running problems
- surging
- missing

☑ **NOTE:** The lack of vaporization with high octane fuel will cause the engine to miss.

OBJECTIVE 14

List problems which may be created by using regular fuel in a vehicle designed to use high octane fuel.

- knocks or pings
- detonation

☑ **NOTE:** During detonation (the most severe and harmful type of engine knock), pistons could receive knock-hole damage, connecting rods could bend, valves could burn, and the engine could be destroyed.

- preignition
- engine noise
- engine hesitation
- engine surge
- loss of power
- poor fuel economy

OBJECTIVE 15

List common engine performance problems.

- engine misses
- engine surge
- loss of power
- poor mileage

OBJECTIVE 16

List common causes of engine mechanical problems.

- lack of lubrication
- overheating
- abuse
- lack of maintenance

☑ **NOTE:** Most engine problems are caused by simple abuse of the vehicle and its component parts. Each vehicle is designed to perform at a particular level in a particular work environment. Operating outside the specifications as outlined in the service manual almost always leads to serious problems. Operator abuse such as revving the engine to an excessive rpm level results in abnormal heat build-up and accelerates wear of critical moving parts. Overload will cause the engine to break down more quickly. Common overload problems are caused by towing trailers that are too large or too heavy or carrying loads above maximum recommended weight.

OBJECTIVE 17

List common causes of engine lubrication problems.

- **low oil level**

☑ **NOTE:** A simple check of the oil dipstick will reveal this problem. Low oil levels can cause severe damage to crankshaft and valve train components.

- **restricted oil galleries**

☑ **NOTE:** Restricted oil galleries can damage the engine block, crankshaft, and cylinder walls.

- **clogged oil filter or pickup screen**

☑ **NOTE:** A clogged oil filter or pickup screen stops the supply of oil to the oil pump causing lower engine damage.

- **improper oil viscosity**

  ☑ **NOTE:** This is sometimes caused by using the wrong oil. More likely it is caused by fuel leaking into the oil and diluting it.

OBJECTIVE 18

List common causes of engine overheating.

- **low coolant level**

  ☑ **NOTE:** Low coolant level can cause a blown head gasket, worn pistons, or warped engine block, as well as damage to the head and other engine components.

- **defective water pump**

  ☑ **NOTE:** A defective water pump may cause loss of coolant.

- **worn or broken water pump belts**

  ☑ **NOTE:** Ineffective pump belts will cause insufficient circulation of engine coolant.

- **defective thermostat**

  ☑ **NOTE:** If the thermostat is stuck closed, the engine will run hot, impairing lubrication and affecting engine performance. If the thermostat is stuck open, the engine will run cold.

- **restriction in the cooling system**

  ☑ **NOTE:** Such restriction can be caused by rust, scales, or foreign objects.

- **incorrect ignition timing**

  ☑ **NOTE:** Incorrect timing will not only cause the vehicle to overheat, but sometimes damages pistons and rings.

OBJECTIVE 19

Required Activities/
Resources
– Older engine with normal wear and tear

List engine parts that are most frequently affected by normal engine wear and tear.

☞ Examine an older engine with normal wear and tear and note the condition of the parts most frequently affected by normal engine wear and tear.

- pistons and rings
- crankshaft and bearings
- camshaft and valve train parts

☑ **NOTE:** Pistons and rings are often the first engine parts to show excessive wear. When these are worn, the engine loses power, sounds unusually noisy, and uses excessive amounts of oil. The crankshaft and bearings will often show wear when the engine has high mileage. Such wear is almost always accompanied by crankshaft and cylinder damage. Camshaft and valve train parts are usually quicker to show wear because they are often made of softer materials.

OBJECTIVE 20

List the steps of engine inspection.

- **Inspect the vehicle for signs of poor maintenance and abuse.**

- **Check the oil dipstick for acceptable level and condition of oil.**

☑ **NOTE:** Is the crankcase full? Does the oil look clean or dirty? Is there a sticker indicating when the vehicle was last serviced?

- **Check beneath the vehicle for leaking fluids.**

☑ **NOTE:** Check the type of fluid—oil, hydraulic fluid, coolant, and transmission fluid are all possibilities. Be aware that fluids may leak from one location but run along hoses or structural parts and strike the ground some distance away. Check carefully for the actual location of the leak.

- **Check for unusual smells.**

☑ **NOTE:** Gasoline odors may mean a flooded carburetor or a leaking fuel line. A burning odor may mean overheating or simply a dirty engine compartment.

- **Examine all belts and hoses for wear and tear.**

☑ **NOTE:** Loose belts can lead to overheating, poor air conditioner performance, and fluctuations in charging. Frayed belts are often hidden beneath pulleys.

- **Check for weak hoses and loose hose connections.**

  ☑ **NOTE:** A weak spot in a hose may not be apparent, but if a hose feels weak when squeezed, it probably is.

OBJECTIVE 21 **Complete Job Sheet 5.**

OBJECTIVE 22 **Match colors of exhaust to the condition or problem indicated by the color.**

- **colorless** — normal

  ☑ **NOTE:** Normal exhaust is colorless after the vehicle is fully warmed up.

- **blue-gray** — excessive oil consumption

  ☑ **NOTE:** This may be caused by excessive wear of the valves, seals, or piston rings. Worn rings are indicated when the smoke appears during acceleration. A compression test will usually identify the cause.

- **black** — too much fuel in the air-fuel mixture or incomplete burning of a normal air-fuel mixture

- **white** — water, coolant, or transmission fluid leakage into the cylinders

  ☑ **NOTE:** Leakage into the cylinders may be caused by a crack in the block or head, but is most often caused by a defective head gasket. When there is coolant in the combustion chamber, the engine may miss, especially in the first few minutes of operation. There may be a brownish contamination in either the oil or the coolant, and the coolant level will frequently be low. Newer vehicles with catalytic converters will often show white smoke at the tail pipe when cold; however, the smoke should disappear within a minute or two. If the vehicle has an automatic transmission with a vacuum modulator, a defective modulator would allow transmission fluid to enter the engine and be burned as white smoke.

OBJECTIVE 23 **Describe an abnormal exhaust odor and the problem it indicates.**

- **rotten egg odor** — too little oxygen in the air-fuel mixture

  ☑ **NOTE:** If the vehicle has a catalytic converter, there may be a slight rotten egg odor in the exhaust. This is normal. However, if the rotten egg odor is strong or seems to linger in the air, it indicates too little oxygen in the air-fuel mixture. This may be eliminated by properly adjusting the carburetor or fuel injection and checking the air management system for proper function.

OBJECTIVE 24 **Complete Assignment Sheet 2.**

OBJECTIVE 25 **Complete Job Sheet 6.**

OBJECTIVE 26 **Complete Assignment Sheet 3.**

OBJECTIVE 27 **Complete Job Sheet 7.**

OBJECTIVE 28 **Complete Job Sheet 8.**

OBJECTIVE 29 **Match the names of engine diagnostic tests to the engine conditions they evaluate.**

- **vacuum test** — measures the negative pressure (vacuum) produced by the engine
- **cylinder power balance test** — indicates which cylinders are not producing their share of power
- **cylinder compression test** — measures the amount of pressure produced during the engine compression stroke
- **cylinder leakage test** — measures the amount of air that leaks from each combustion chamber
- **oil pressure test** — measures lubrication system pressure in the engine

OBJECTIVE 30 **Name types of engine test equipment shown in illustrations.**

See Objective 31.

OBJECTIVE 31

Required Activities/
Resources
- Transparency Masters 3, 4, 5, 6, & 7
- Engine diagnostic test equipment

Match the names of engine test equipment to the information which can be obtained with that equipment.

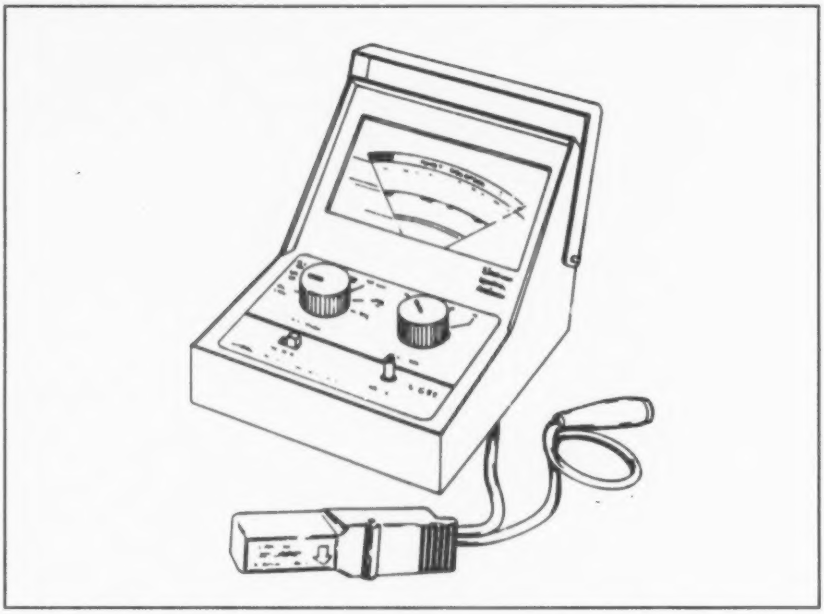
Look at transparencies 3, 4,5 , 6, and 7 as your instructor explains the information that can be obtained with each item of equipment.

Examine various examples of test equipment displayed by your instructor.

WORDS YOU SHOULD KNOW	
rpm	revolutions per minute
psi	pounds per square inch
Hg	the chemical element mercury
kPa	metric version of pounds per square inch

- **tach-dwell meter** — measures both engine speed (rpm) and dwell angle (Figure 3)

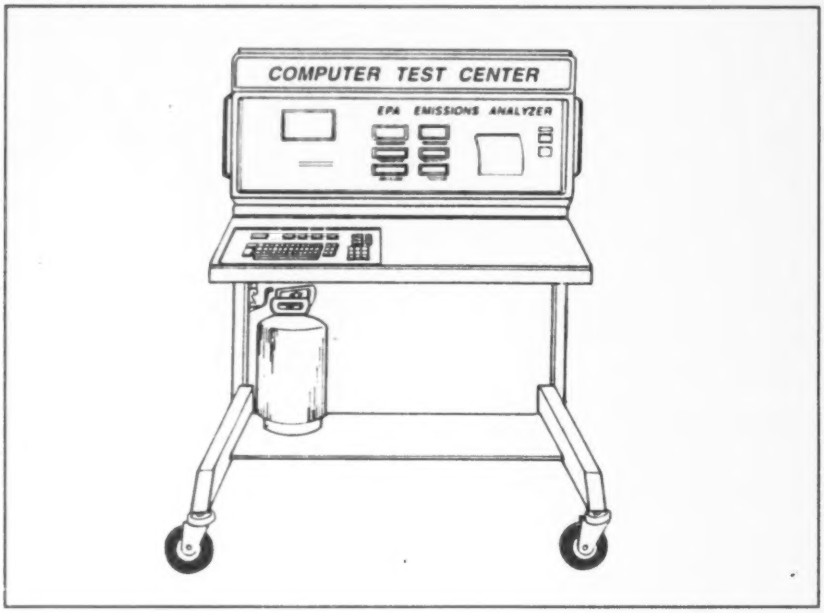
FIGURE 3



NOTE: Tach-dwell meters are used on engines with contact point ignitions or computer-controlled carburetors.

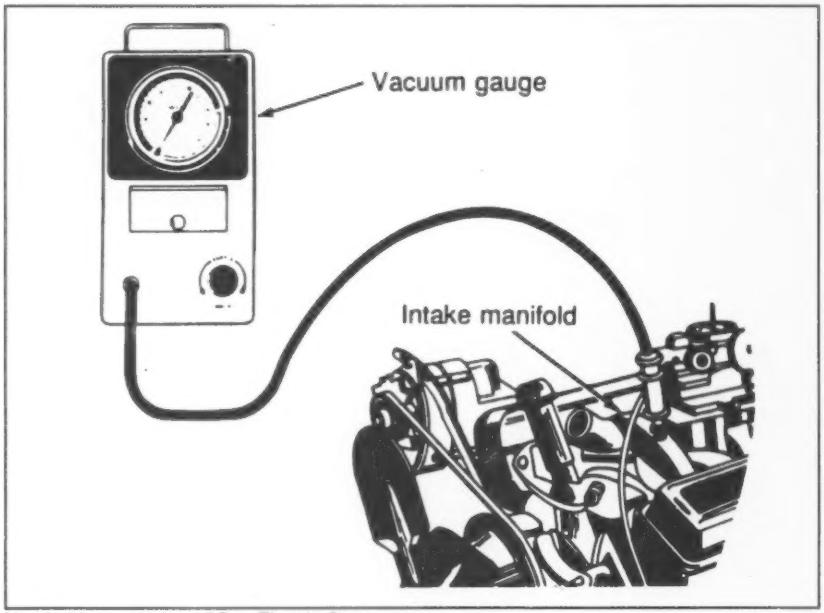
- **exhaust gas analyzer** — measures the chemical content of the engine's exhaust (Figure 4)

FIGURE 4


COMPUTER TEST CENTER
EPA EMISSIONS ANALYZER

- **vacuum gauge** — measures negative pressure (vacuum) (Figure 5)

FIGURE 5

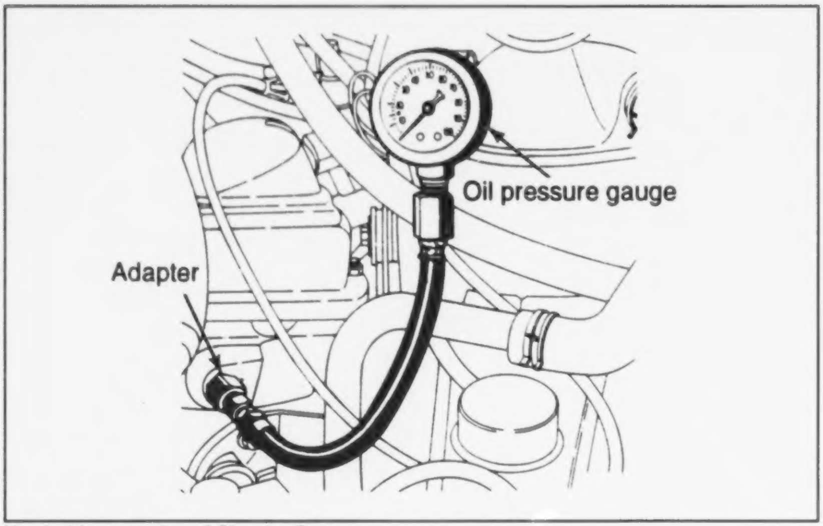

Vacuum gauge
Intake manifold

Used with permission of Sun Electric Corp.

☑ **NOTE:** Vacuum is measured in Hg (inches of Mercury) or metric kilograms per square centimeter.

- **pressure gauge** — measures pressure (Figure 6)

FIGURE 6

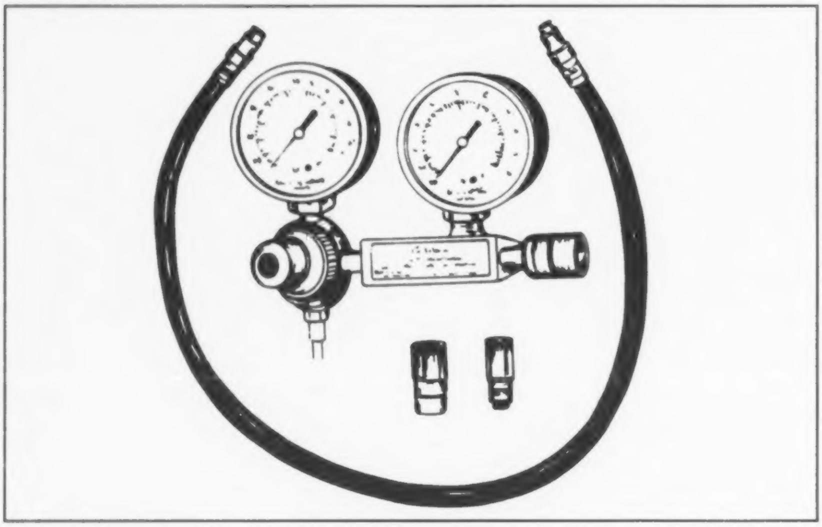


Used with permission of Chrysler Corp.

☑ **NOTE:** Pressure is measured in psi and/or kPa. It is not uncommon for an Engine Performance Technician to have several pressure gauges designed for specific jobs. Pressure is commonly measured for the fuel pump, pressure regulator, engine oil, turbo boost pressure, or cylinder compression.

- **cylinder leakage tester** - measures the amount of air leakage out of the engine combustion chambers (Figure 7)

FIGURE 7



OBJECTIVE 32

List the steps in making a diagnostic road test.

1. **Listen.**

   ☑ **NOTE:** The first step in making a good road test is listening to the vehicle's owner. What is he or she telling you about the behavior of the vehicle? About the vehicle's history?

2. **Ask Questions.**

   ☑ **NOTE:** After listening carefully, use your knowledge to ask questions that will help you in your diagnosis of the vehicle's problems. What? How often? Under what conditions? Is the behavior constant or occasional? How long has the problem existed?

3. **Observe.**

   ☑ **NOTE:** Let your observations give you important information about the vehicle that will help you in your analysis. How old is the vehicle? What is the mileage? Does the vehicle appear to have ever been in an accident? Look for obvious clues such as oil leaks, tire wear, or poor springs.

4. **Consult the service manual troubleshooting guide and all technical service bulletins.**

   ☑ **NOTE:** Check the troubleshooting guide in the service manual for the problems you suspect *before you take the vehicle on the road.* See what types of tests you should make on the vehicle and what symptoms you will be looking for while you are on the road. Do you need to drive at highway speeds? Will you be testing response during a sudden stop? Should you be listening for a noise? Watching for a certain behavior? Check the technical service bulletins (TBSs) for information not found in the troubleshooting guide. Know beforehand what you will need to do and observe.

5. **Make the road test.**

   ☑ **NOTE:** Drive the vehicle, making the tests suggested by the service manual. Check the owner's information by driving it under the conditions at which the problem has been noticed. What does the noise sound like? What is the nature of the vibration? Be sure to use all normal safety precautions before driving an unfamiliar vehicle: check fluid levels, brake operation, buckle your seat belt, etc. It's also a good idea to road test vehicles over the same routes in case there is a breakdown.

6. **Note the results.**

☑ **NOTE:** If you make a number of checks, you may want to pull over and write down a few notes about the vehicle's performance, or you could do this when you return to the shop.

7. **Make a preliminary diagnosis.**

☑ **NOTE:** Consider all the information you have gathered and make an initial evaluation of the vehicle's problems.

8. **Check your diagnosis.**

☑ **NOTE:** You will need to check your diagnosis by rechecking the service manual, making a visual examination, or conducting other tests. Always make the simpler, less time-consuming tests first.

OBJECTIVE 33 **Complete Assignment Sheet 4.**

OBJECTIVE 34 **Complete Assignment Sheet 5.**

ASSIGNMENT SHEET 1

EVALUATING ENGINE CONDITION

5

Name ______________________________ Score __________

OBJECTIVE 11

Interpret cylinder compression test results.

INTRODUCTION

In diagnosing a vehicle with engine performance problems, it is always a good idea to conduct a cylinder compression test. However, this test will provide useful information only if the person doing the test knows what the results mean. Knowing how to interpret compression test results will make the diagnostic process easier and more accurate.

EQUIPMENT AND SUPPLIES

- Job Sheet 3, objective 9
- Handout 1, Compression Diagnosis Chart

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

Cognitive Activities
- Draw conclusions
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure

Use Job Sheet 3 and Handout 1 to help you answer the following questions.

_____ 1. Which of the following does a cylinder compression test measure?

A. Ignition timing
B. The efficiency of each cylinder
C. Which component is damaged
D. None of the above

_____ 2. How close together must all cylinders' compression readings be in order to be considered acceptable?

A. Within 5% of each other
B. Within 10 % of each other
C. Within 15% of each other
D. Within 25% of each other

_____ 3. A cracked cylinder head should be suspected when the readings are which of the following?

A. Too low
B. Too high

_____ 4. When making a dry compression test, you note that it takes four compression cycles for a cylinder to reach its highest compression reading. You make the test again to verify your results, and it still takes four compression cycles. What defect is indicted?

A. Sticky ring or valve
B. Defective head gasket
C. Burned piston
D. Worn cylinder parts

_____ 5. Making a wet compression test checks for possible damage in what two components?

A. Valves and cylinder head
B. Head gasket and cylinder head
C. Pistons and piston rings
D. Pistons and valves

_____ 6. When the cylinder compression test record low readings that stay the same on wet compression test and dry compression test, what part is indicated as defective?

A. Either rings are weak or the piston is bad.
B. Piston is good but the rings are weak.
C. Cylinder is dry
D. None of the above

_____ 7. What corrective action should be considered if the cylinder compression test reading is low and a cracked cylinder head is discovered?

A. Adjust valve.
B. Repair or replace cylinder head.
C. Both A & B
D. None of the above

_____ 8. A defective head gasket is confirmed as the defective part. What corrective action should be taken?

A. Replace head gasket.
B. Replace head gasket; surface head.
C. Replace pistons.
D. All of the above

ASSIGNMENT SHEET 2

EVALUATING ENGINE CONDITION

5

Name ______________________________ Score __________

OBJECTIVE 24

Diagnose the cause of unusual exhaust color, odor, and sound.

INTRODUCTION

One source of valuable information for engine diagnosis is the engine exhaust. An engine computer analyzer or an exhaust gas analyzer can provide information about the chemical content of the exhaust, but exhaust color, odor, and sound can also give you important clues about engine condition. All of this information should be considered in order to make an informed diagnosis.

When the engine is running at idle, the tailpipe should have a smooth, even sound and feel. Burned or leaking valves will cause the exhaust to sound irregular. The sound will even out when rpm is increased.

EQUIPMENT AND SUPPLIES

- Information Sheet, objectives 22 and 23

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use standard references

Functional Reading
- Use content area vocabulary

Cognitive Activities
- Draw conclusions
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure

Use Information Sheet objectives 22 and 23 and this Assignment Sheet to help you answer the following questions.

____ 1. What is the possible cause if black smoke appears from the exhaust during acceleration?

A. Fuel only partially burned
B. Too much fuel in the air-fuel mixture
C. Too little fuel in the air-fuel mixture
D. Both A and B

____ 2. What problem should an Engine Performance Technician look for when the exhaust odor smells strongly of rotten eggs?

A. Burned or leaking valves
B. Too little oxygen in the air-fuel mixture
C. Both A and B
D. None of the above

____ 3. What color might the exhaust be if there was a crack in the block or head?

A. Colorless
B. Blue-gray
C. Black
D. White

____ 4. White exhaust can be contributed to which of the following causes?

A. Water in the air-fuel mixture
B. Transmission fluid leak into the engine
C. Coolant getting into the cylinders
D. All of the above

____ 5. Which of the following is a problem indicated by abnormal exhaust odor?

A. Too little oxygen in the air-fuel mixture
B. Too little fuel in the air-fuel mixture
C. Excessive oil consumption
D. All of the above

____ 6. Blue-gray exhaust is a result of which of the following possible causes?

A. Fuel partially burned
B. Too much fuel in the air-fuel mixture
C. Excessive oil consumption
D. None of the above

____ 7. The exhaust of a vehicle equipped with a catalytic converter smells like which of the following?

A. Slight rotten egg odor
B. Strong rotten egg odor
C. Gasoline
D. None of the above

____ 8. What color is normal exhaust?

A. White
B. Black
C. Colorless
D. Blue-gray

ASSIGNMENT SHEET 3

EVALUATING ENGINE CONDITION

5

Name ______________________________ Score __________

OBJECTIVE 26

Interpret vacuum gauge readings.

INTRODUCTION

On all engines, correct intake vacuum is a very important part of an engine. It not only provides suction to the fuel system but also controls various mechanical and electrical sensors that maintain proper engine performance. When diagnosing engine performance problems on computer-controlled carburetors and fuel injection systems, it is important to know what the engine's vacuum readings are compared to the manufacturer's specifications.

EQUIPMENT AND SUPPLIES

- Handout 2, Interpreting Engine Vacuum Gauge Readings

INSTRUCTIONS

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

Math Application
- Use English and metric measures

General Science
- Investigate/apply technology

Physical Science
- Investigate/apply physical laws

Job Acquisition/ Development
- Master specific job task/procedure

Use Handout 2 to help you answer the following questions.

____ 1. What is the normal vacuum reading?

A. 12-17 inches of Hg
B. 17-21 inches of Hg
C. 24-30 inches of Hg
D. 30-34 inches of Hg

____ 2. A vacuum reading of 3, with the needle holding steady, could indicate which of the following?

A. Burned valve
B. Incorrect timing
C. Uneven compression
D. Carburetor problem

____ 3. A vacuum gauge reading that fluctuates between high and low readings may be caused by a blown head gasket between side-by-side cylinders. What test will check this diagnosis?

A. Timing test
B. Cylinder power balance test
C. Cylinder compression test
D. Cylinder leakage test

_____ 4. During an engine vacuum test, the needle drops to zero as engine rpm is increased. Which of the following problems could be indicated?

A. Restricted exhaust system
B. Burned or leaking valves
C. Both A and B
D. None of the above

_____ 5. If you suspect the engine you are testing has worn valve guides, what vacuum readings would you expect to find?

A. Needle fluctuates between high and low reading.
B. Needle fluctuates rapidly at idle, then steadies as rpm is increased.
C. Needle fluctuates slowly, ranging 4 or 5 points.
D. Needle holds steady at an extremely low reading.

_____ 6. If the vacuum gauge needle drops to a low reading, returns to normal, and then drops back at a regular interval, what is indicated?

A. Burned or leaking valve
B. Worn valve guides
C. Leaking piston rings
D. Air leak at the intake manifold

_____ 7. While road testing a vehicle that has completed a tune-up, a slight performance problem is noticed. While rechecking the vehicle's engine vacuum readings you find the needle fluctuates very slowly ranging 4 and 5 inches. Which of the following could cause this reading?

A. Contaminated fuel
B. Incorrect timing
C. Clogged PCV valve
D. Spark plug gap too narrow

_____ 8. When road testing a vehicle the engine idles fine but has poor performance when accelerating quickly. The vacuum test indicates normal at idle but drops to near zero when the engine is accelerated. What is the most likely problem?

A. Lean mixture
B. Incorrect timing
C. Restricted exhaust system
D. Blown head gasket

ASSIGNMENT SHEET 4

EVALUATING ENGINE CONDITION

Name ______________________ Score __________

OBJECTIVE 33

Verify driver's complaint.

INTRODUCTION

The first action taken to verify a driver's complaint is to listen carefully to the driver's descriptions of the complaint and then ask specific questions. An Engine Performance Technician must be observant and have a systematic approach to solving many vehicle problems. Time can be saved by working carefully and exploring probable causes in a organized method. First impressions are very important because of the wide variety and complexity of the systems involved. Any obvious clues should be explored first. A good road test will help the Engine Performance Technician get the right answers. A road test is more than just a ride around the block. The vehicle must be driven in a way that tests it for the suspected problems, allowing the road test to provide answers. Diagnostic tests are often critical to verifying complaints, but it is always wise to make the simpler, quicker, and less expensive tests first. With the proper understanding and reading of diagnostic tests, verification of engine problems becomes more exact and efficient.

EQUIPMENT AND SUPPLIES

- Information Sheet, all objectives

INSTRUCTIONS

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

Interactive Communications
- Apply questioning techniques

Use the objectives in the Information Sheet to help you answer the following questions.

_____ 1. What question is *not* an appropriate question to ask a driver in the initial conversation?

A. How long has the problem existed?
B. How often does the problem occur?
C. Under what conditions does it occur?
D. Why does the problem occur?

Teamwork/Cooperative
- Select/apply appropriate behavior

Job Acquisition/ Development
- Master specific job task/procedure

____ 2. Which of the following steps is in a proper road test?

A. Drive the vehicle wide open with sudden stops.
B. Make quick starts and sharp turns.
C. Drive the vehicle in a way that tests the vehicle for suspected problems.
D. Both A and B

____ 3. Which of the following is an important skill of an Engine Performance Technician in solving engine problems?

A. Mechanical skills
B. Listening skills
C. Observation skills
D. All of the above

____ 4. Technician A says that the only correct place to look for a part leaking fluid is right above the leak. Technician B says that the leaking part may not be right above the leak. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

____ 5. Which of the following is an engine problem that can be caused by a loose belt?

A. Overheating
B. Poor air conditioner performance
C. Fluctuations in charging
D. All of the above

____ 6. Technician A says that using a regular fuel in a vehicle designed to use high octane fuel can create engine running problems. Technician B says that using high octane fuel in a vehicle designed to use regular fuel can also cause problems. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____ 7. Which of the following engine parts are most frequently affected by normal engine wear and tear?

A. Pistons and rings
B. Crankshaft and bearings
C. Camshaft and valve train parts
D. All of the above

_____ 8. What equipment would you use to measure the vacuum in the intake manifold?

A. Tach-dwell meter
B. Vacuum gauge
C. Pressure gauge
D. Cylinder leakage tester

_____ 9. Technician A says that a worn belt can cause engine overheating. Technician B says that the coolant is circulated by the water pump. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

760

ASSIGNMENT SHEET 5

EVALUATING ENGINE CONDITION

5

Name ______________________________ Score __________

OBJECTIVE 34

Diagnose the cause of unusual engine noise and vibration problems.

INTRODUCTION

Engine noises need to be heard instead of described. Only experience will allow the technician to fully use sounds as part of a successful diagnosis. There are, however, some important things to remember before beginning to evaluate sounds.

Guidelines:

- Begin your evaluation as soon as you start the engine.
- Be aware of the transition between a cold and warm engine, and be alert to changes in sound.
- Try to isolate the location of the sound.
- Metal parts are good conductors of sound and may mislead the Engine Performance Technician as to the location of the sound.
- Use a stethoscope to isolate elusive sounds.
- After diagnosing the sound as coming from the engine itself, try to characterize the sound and make a mental note of it for future reference.

EQUIPMENT AND SUPPLIES

- Handout 3, Engine Noise Diagnosis Chart

INSTRUCTIONS

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure

Use Handout 3 and this Assignment Sheet to help you answer the following questions.

____ 1. When an engine has a heavy metallic knock, which of the following is a possible cause?

A. Worn crankshaft bearings
B. Damaged thrust bearings
C. Both A and B
D. Neither A nor B

____ 2. A metallic double knock in the engine may mean that a piston pin or bushing is worn. If this is the case, what corrective action should be taken?

A. Replace the piston pin or bushing
B. Adjust valve timing
C. Service or replace the pistons
D. None of the above

____ 3. Loud internal engine noises could indicate which of the following?

A. Coolant in the cylinder
B. Slack timing chain/belt
C. Both A and B
D. Neither A or B

____ 4. What tool can be used to help the Engine Performance Technician get a better idea of the location and type of sound?

A. Hammer
B. Stethoscope
C. Oscilloscope
D. Tach-dwell meter

____ 5. The driver complains of a squeal in the engine. Which of the following is a possible cause?

A. One or more loose motor mounts
B. Worn or loose belts
C. Both A and B
D. Neither A nor B

JOB SHEET 1

EVALUATING ENGINE CONDITION

5

Name ______________________________

OBJECTIVE 7

Verify correct valve timing.

INTRODUCTION

Power transmitted from the crankshaft to the camshaft and the valve train is dependent upon the relationship of a number of interdependent parts. If cam lobes, timing gears, chains, or belts are worn, stretched, or broken, the timing of the valves is directly affected, resulting in poor engine efficiency and performance. Measure cam lobe and journal wear, camshaft end play, and cam bearing clearance for correct measurements. Always refer to manufacturer's instructions and tables when using diagnostic equipment. Manufacturers usually recommend that timing belts be replaced every 60,000 miles or 5 years, whichever comes first.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 2
EVALUATING ENGINE CONDITION

Name ____

OBJECTIVE 8

Adjust valves.

INTRODUCTION

When mechanical lifters are used in an engine, the valves will require periodic adjustment. Proper valve adjustment is important to the performance of the engine. If a valve opens too much or not enough, it will upset the amount of air-fuel mixture pulled into the cylinder. It may also affect valve lift and duration. If the valve train is too tight and there is inadequate clearance, the valve will not close properly or may be held open. This can result in combustion heat burning the valve. If the valve train is too loose, valve train noise from rockers striking the valve stems will result, increasing part wear and damage. This will affect combustion and reduce engine efficiency.

To determine whether or not valves need adjusting, look for signs of improper valve timing. Look at valves for signs of heat damage. Listen for valve train noise. Look for signs of increased wear and tear on the valve train. Some engine manufacturers recommend cold valve adjustment while others require that the engine be warmed to full operating temperature. Always refer to the appropriate service manual for the exact procedure.

EQUIPMENT AND SUPPLIES

- Vehicle with mechanical lifters
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Research and Reference
- Use standard references

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB
SHEET 3

EVALUATING ENGINE CONDITION

5

Name ______________________________

OBJECTIVE 9

Perform cylinder compression tests.

Required Activities/
Resources
– Handout 1

📖 Study Handout 1, Compression Diagnosis Chart, as your instructor explains its use.

INTRODUCTION

Cylinder compression tests measure the efficiency of each cylinder. During these tests, the technician will measure each cylinder with a dry compression test, and then if necessary, a wet compression test. The only difference between the two types of compression tests is that in a wet compression test the technician squirts about a tablespoon of engine oil into the cylinder before the test is made.

Once you perform a cylinder compression test on an engine, you should compare your readings with vehicle specifications. A cylinder compression test can confirm that there is internal engine damage, but you cannot make a firm diagnosis of what parts are damaged from this test. A cylinder leakage test is needed to make this type of diagnosis. If any cylinder or cylinders fall well below specifications, you should perform a cylinder leakage test to make the actual diagnosis of the problem. Cylinder compression tests are very commonly done and should be made on every engine undergoing diagnosis.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Handout 1, Compression Diagnosis Chart
- Masking tape
- Pen and paper
- Compression tester
- Appropriate spark plug socket, extension, and ratchet
- Spark plug wire removing pliers
- Squirt can with oil
- Compressed air source
- Air nozzle
- Remote starter switch
- Basic hand tool set

IMPORTANT: The battery on the vehicle you are using should be fully charged or the cylinder compression tests will not be accurate.

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references
- Use in-book reference tools

Functional Reading
- Interpret graphics and symbols
- Use content area vocabulary

Data Analysis and Display
- Collect/record data

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Physical Science
- Investigate/apply physical laws

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Perform a dry compression test Yes No

1. Place vehicles with automatic transmission in park and manual transmissions in neutral. ____ ____
2. Raise the hood. ____ ____
3. Start the engine and let the engine idle until the temperature gauge moves into the normal range. ____ ____

⚠ **DANGER:** UNVENTED EXHAUST FUMES in a closed building can cause death. ALWAYS CONNECT THE VEHICLE'S EXHAUST TO A VENT HOSE WHEN YOU RUN AN ENGINE IN A CLOSED SHOP.

---

4. Turn off the engine. ____ ____
5. Tag each spark plug wire with masking tape, marking them to indicate to which spark plug they should be attached. ____ ____

⚠ CAUTION: ENGINES THAT HAVE BEEN RUNNING are hot. USE CAUTION WHEN WORKING AROUND ENGINES THAT HAVE BEEN RUNNING.

---

6. Use spark plug wire removing pliers to remove the spark plugs wires from the spark plugs. ____ ____
7. Use compressed air and an air nozzle to blow any dirt from around the spark plugs. ____ ____
8. Use the appropriate spark plug socket, extension, and ratchet to remove the spark plugs. ____ ____

Yes No

9. Check the condition of the spark plugs. ____ ____

☑ **NOTE:** If one or more are in bad condition, note the cylinder from which it/they came. This can give you a clue regarding potential cylinder problems.

10. Have your instructor show you how to block the throttle and choke plates open on the vehicle you are working on. ____ ____

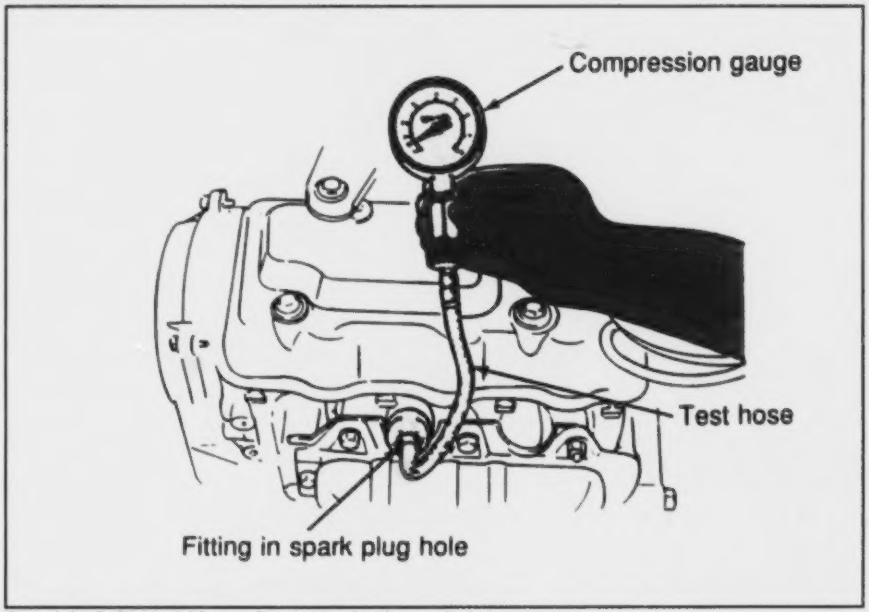
☑ **NOTE:** The air cleaner may have to be removed in order to reach the throttle and choke plates.

11. Connect the remote starter switch to the engine. ____ ____

☑ **NOTE:** Remote starter switches connect to different vehicles in different ways. If you don't know how to connect a remote starter switch to the vehicle you are working on, have your instructor show you how.

12. Fit the compression tester into a spark plug hole. (Figure 1) ____ ____

FIGURE 1



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Yes No

13. Look at the gauge on the compression tester as you use the remote starter to crank the engine for at least 5 compression cycles. ____ ____

IMPORTANT: If the vehicle's battery is not fully charged or if the engine does not crank at normal speed, the compression readings for this test will not be accurate.

14. Note any increases in gauge readings between compression cycles. ____ ____

15. Write down the highest reading reached during the 5 compression cycles and the rate of increase between each cycle. ____ ____

16. Remove the compression tester from the spark plug hole, and install it into another spark plug hole. ____ ____

17. Repeat steps 13 - 16 for each remaining cylinder, making sure you write down the results for each cylinder accurately and separately after each test. ____ ____

18. Use the remote starter switch to turn off the engine. ____ ____

19. Compare the results of the readings. ____ ____

20. If there is an inconsistency in the rate of increase between compression cycles from cylinder to cylinder, repeat steps 13 through 16 to verify your results. ____ ____

☑ **NOTE:** The compression reading for a cylinder should reach its highest point, or very close to its highest point, within two compression cycles. If the reading comes up quicker on the second test, it is an indication that the cylinder has a sticky ring or valve. If the results are the same, it indicates worn cylinder parts.

Yes No

21. Compare the highest reading obtained from each cylinder with the specifications in the vehicle service manual and with each other. You should proceed and make a wet compression test if any of the following conditions are met: ____ ____

- The highest reading and the lowest reading for the cylinders are more than 15% apart.
- The readings for all the cylinders are less than 100 psi.
- The readings for ¾ of the cylinders are less than manufacturer's specifications.

22. If none of the conditions exist, proceed to step 13 of the wet compression test. ____ ____

PROCEDURE

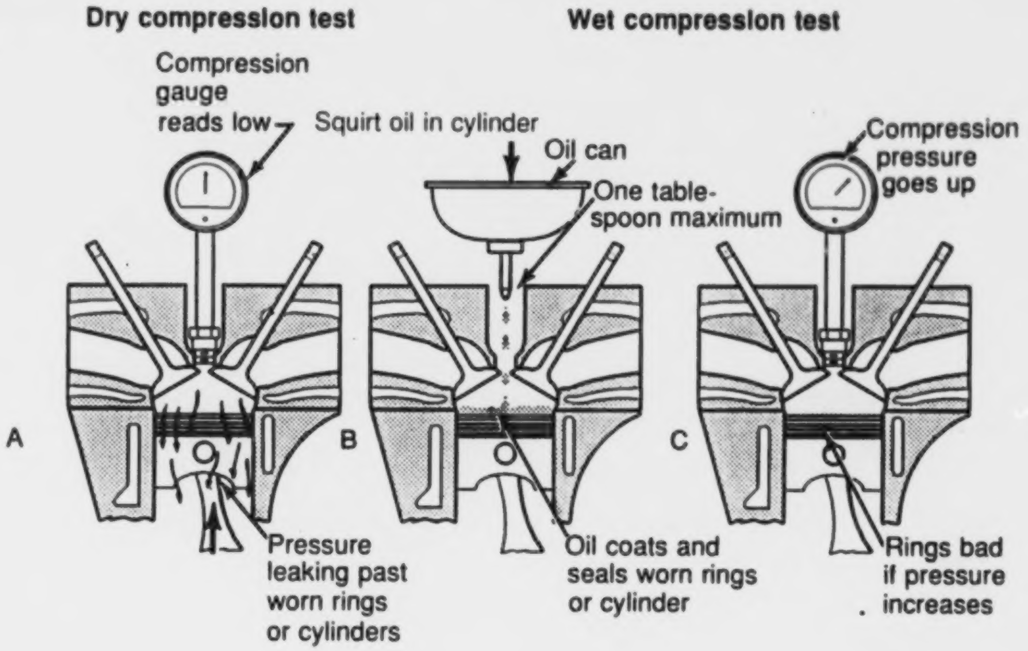
Job Acquisition/ Development

- Master specific job task/procedure

Perform a wet compression test

1. Remove the compression tester from the spark plug hole. ____ ____
2. Squirt approximately one tablespoonful of oil into each spark plug hole. ____ ____
3. Use the remote starter switch to crank the engine several times to distribute the oil in the cylinders. ____ ____
4. Fit the compression tester into a spark plug hole. (Figure 2) ____ ____

FIGURE 2


Dry compression test
Wet compression test
Compression gauge reads low
Squirt oil in cylinder
Oil can
One table-spoon maximum
Compression pressure goes up
A
B
C
Pressure leaking past worn rings or cylinders
Oil coats and seals worn rings or cylinder
Rings bad if pressure increases

	Yes	No
5. Look at the gauge on the compression tester as you use the remote starter to crank the engine for at least 5 compression cycles.	___	___
☑ **NOTE:** It is unnecessary to note any increases in readings between compression cycles.		
6. Write down the highest reading reached during the 5 compression cycles.	___	___
7. Use the remote starter switch to turn off the engine.	___	___
8. Remove the compression tester from the spark plug hole and install it into another spark plug hole.	___	___
9. Repeat steps 5 - 8 for each remaining cylinder, making sure you write down the results for each cylinder accurately and separately after each test.	___	___

Yes No

10. Turn off the engine. ____ ____

11. Compare the readings for each cylinder on the wet compression test and the dry compression test. ____ ____

12. If the cylinder compression test indicates that (1) compression readings show the cylinders are not working within 15% of each other, (2) all the cylinders have compression readings below 100 psi, or (3) the readings for ¾ of the cylinders are less than manufacturer's specifications, you will need to make a cylinder leakage test to help you diagnose the problem(s) in the cylinders involved. ____ ____

☑ **NOTE:** Only a cylinder leakage test can make a sound diagnosis of cylinder problems. However, some generalizations about the diagnosis can be made from the compression test results.

- *If a cylinder's low reading stays the same on both the wet and the dry test:* either the rings are weak or the piston is bad.
- *If a cylinder has a low reading on the dry test, but the reading on the wet test is higher than its dry test reading:* the piston is probably good, but the rings may be weak. The lower reading on the dry test was probably due to a dry cylinder.
- *If a cylinder shows a VERY low reading (near 0°) on both the wet and the dry test:* further testing will be necessary.

13. Reinstall the spark plugs. ____ ____

☑ **NOTE:** If your test results show that you need to make a cylinder leakage test, you may want to do this test before you reinstall the spark plugs.

	Yes	No
14. Use the markings you made on the masking tape to guide you in reattaching the spark plug wires to the correct spark plug.	____	____
15. Remove the remote starter switch.	____	____
16. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 4 EVALUATING ENGINE CONDITION

5

Name ______________________________

OBJECTIVE 10

Perform a cylinder leakage test.

INTRODUCTION

If the cylinder compression test indicates that (1) the engine cylinders are not working within 15% of each other, (2) all the cylinders have compression readings below 100 psi, or (3) the readings for ¾ of the cylinders are less than manufacturer's specifications, you should use the cylinder leakage test to help you diagnose the problem(s) in the cylinders involved. If the cylinder compression test is satisfactory, it is not necessary to make a cylinder leakage test.

In a cylinder leakage test, a cylinder leakage tester is screwed into the spark plug hole of a cylinder. When compressed air is attached to the leakage tester, it applies air pressure to the combustion chamber. The technician then notes where the compressed air can be seen or heard hissing as it escapes. The locations where the air is escaping indicate the defective parts. This test can identify a defective head gasket, valves, piston rings, pistons or cylinders.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Masking tape
- Pen and paper
- Cylinder leakage tester
- Shop cloth
- Appropriate spark plug socket, extension and ratchet
- Spark plug wire removing pliers
- Remote starter switch
- Compressed air source
- Air nozzle
- Short length of heater hose
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Interpret graphics and symbols
- Interpret abbreviations/ acronyms

General Science
- Use scientific instruments
- Investigate/apply technology

Physical Science
- Investigate/apply physical laws

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

1. Place vehicles with automatic transmission in park and manual transmissions in neutral. ____ ____

2. Raise the hood ____ ____

3. Loosen the radiator cap to prevent pressure build-up. ____ ____

4. Start the engine and let the engine idle until the temperature gauge moves into the normal range. ____ ____

⚠ **DANGER:** UNVENTED EXHAUST FUMES in a closed building can cause death. ALWAYS CONNECT THE VEHICLE'S EXHAUST TO A VENT HOSE WHEN YOU RUN AN ENGINE IN A CLOSED SHOP.

---

5. Turn off the engine. ____ ____

6. Tag each spark plug wire with masking tape, marking them to indicate to which spark plug they should be attached. ____ ____

⚠ **CAUTION:** ENGINES THAT HAVE BEEN RUNNING are hot. USE CAUTION WHEN WORKING AROUND ENGINES THAT HAVE BEEN RUNNING.

---

7. Use the spark plug wire removing pliers to remove the spark plug wires from the spark plugs. ____ ____

8. Use compressed air and an air nozzle to blow any dirt from around the spark plugs. ____ ____

9. Use the appropriate spark plug socket, extension, and ratchet to remove the spark plugs. ____ ____

10. Have your instructor show you how to block the throttle and choke plates open on the vehicle you are working on. ____ ____

☑ **NOTE:** The air cleaner may have to be removed in order to reach the throttle and choke plates.

Yes No

11. Use a shop cloth to remove the radiator cap. ____ ____

⚠ **WARNING:** COOLANT IS HOT AND UNDER PRESSURE in a vehicle that has been running. REMOVE THE CAP SLOWLY TO PREVENT BEING BURNED BY THE HOT COOLANT.

---

12. Connect the remote starter switch to the engine. ____ ____

☑ **NOTE:** Remote starter switches connect to different vehicles in different ways. If you don't know how to connect a remote starter switch to the vehicle you are working on, have your instructor show you how.

⚠ **WARNING:** TURNING THE VEHICLE'S IGNITION ON during the cylinder leakage tests could cause electric shock. BE SURE THE VEHICLE'S IGNITION SWITCH IS TURNED OFF WHILE YOU PERFORM THE CYLINDER LEAKAGE TESTS.

---

13. If necessary, test and zero the leakage gauge on the cylinder leakage tester. ____ ____

☑ **NOTE:** To zero the gauge, connect compressed air to the gauge inlet hose. Connect the air nozzle to the outlet side of the leakage gauge. Release air through the nozzle and note the movement of the gauge. Turn off the air. The gauge should return to zero. If it doesn't, set the gauge to zero manually and retest it.

14. Put a wrench on the crankshaft pulley and rotate the engine until the piston is at TDC (top dead center) of its compression stroke. ____ ____

IMPORTANT: The piston must be at the TDC of its compression stroke during the leakage test or you will not obtain an accurate reading.

Yes No

15. Screw the air hole adapter of the cylinder leakage tester into the spark plug hole and tighten. ____ ____

16. On vehicles with a manual transmission, shift to 1st gear and block the wheels. ____ ____

☑ **NOTE:** On vehicles with an automatic transmission, have your instructor show you how to keep the engine from turning.

17. Connect the output side of the leakage tester to the hole adapter. ____ ____

18. Connect the compressed air and record the gauge reading. ____ ____

☑ **NOTE:** Compressed air can push pistons down from the TDC point on engines with automatic transmissions. It may be necessary to bump the piston back into place using the remote starter switch before you take your gauge reading.

19. Use a length of heater hose to help you listen for a hissing sound at the following locations:

- intake manifold — indicates a leaking intake valve ____ ____
- oil filler cap — indicates worn piston rings, scored pistons or cylinder walls ____ ____
- tail pipe — indicates burned or leaking exhaust valves ____ ____
- adjoining spark plug holes — indicates a leaking head gasket between the two cylinders ____ ____

☑ **NOTE:** Where you hear the air exiting indicates the component that is at fault.

20. Look in the radiator for bubbles of compressed air in the coolant. ____ ____

☑ **NOTE:** Bubbles indicate a leaky head gasket, cracked block, or a cracked cylinder head.

	Yes	No
21. Record the locations where you heard hissing sounds.	____	____
22. Repeat steps 17 through 21 on all remaining cylinders.	____	____
23. Compare the list of your findings with the list in step 19 to diagnose faulty parts.	____	____
24. Remove the compressed air source from the cylinder leakage tester.	____	____
25. Remove the leakage tester from the hole adapter.	____	____
26. Remove the hole adapter from the spark plug hole.	____	____
27. Replace the spark plugs.	____	____
28. Replace the spark plug wires.	____	____
29. Remove the remote starter switch.	____	____
30. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1

Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 5

EVALUATING ENGINE CONDITION

5

Name ________________________________

OBJECTIVE 21

Inspect an engine assembly for leaks.

INTRODUCTION

A visual inspection of the engine is usually one of the first steps in diagnosing engine condition. The process may seem simple, but proper evaluation is crucial to the later steps you will perform. The four liquids you will be looking for are fuel, coolant, oil, and hydraulic fluid. You may not see liquid at a suspected leak site. There may be corrosion or other deposits which indicate the presence of an intermittent leak. Develop a systematic approach to inspecting each engine you are asked to diagnose. It will save you time.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Information Sheet, objective 20
- Hoist or jack stands
- Shop light
- Replacement parts as needed
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references
- Use in-book reference tools

Functional Reading
- Interpret graphics and symbols

Yes No

1. Raise the hood.
2. Use a shop light to help you inspect around the radiator cap for leaks. ____ ____
3. If indications of a leak are found, replace the radiator cap with a new one. ____ ____

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure

	Yes	No
4. Check the filler neck for distortion or seepage.	____	____
5. If defects are found, the radiator will have to be repaired at a radiator repair shop.	____	____
6. Inspect around the clamps of the cooling system hoses.	____	____
7. If you find leaks, tighten the clamps or replace the clamps and/or hoses as needed.	____	____
8. Inspect each hose and squeeze each one in the middle.	____	____
9. If any hose feels weak or shows signs of cracking, replace it.	____	____
10. Inspect the carburetor or the fuel injection system for fuel leaks.	____	____
11. If there are leaks, ask your instructor for help in determining the cause of the leak.	____	____
12. Notice any fuel odors which may be an indication of leaks.	____	____
13. If you notice such odors, more in-depth inspection will be needed. See your instructor for assistance.	____	____
14. Inspect fuel lines and fittings for damage, wear, or dripping fuel.	____	____
15. If found, tighten the fittings or replace lines and fittings as required.	____	____
16. Inspect the area around the fuel pump for evidence of fuel leaks.	____	____
17. If found, repair the lines or replace the pump as necessary.	____	____
18. Inspect the engine head gasket for oil seepage.	____	____

☑ **NOTE:** Figure 1 shows the location of important sealing gaskets in an engine. Rocker cover gaskets are also commonly called *valve cover gaskets*.

FIGURE 1

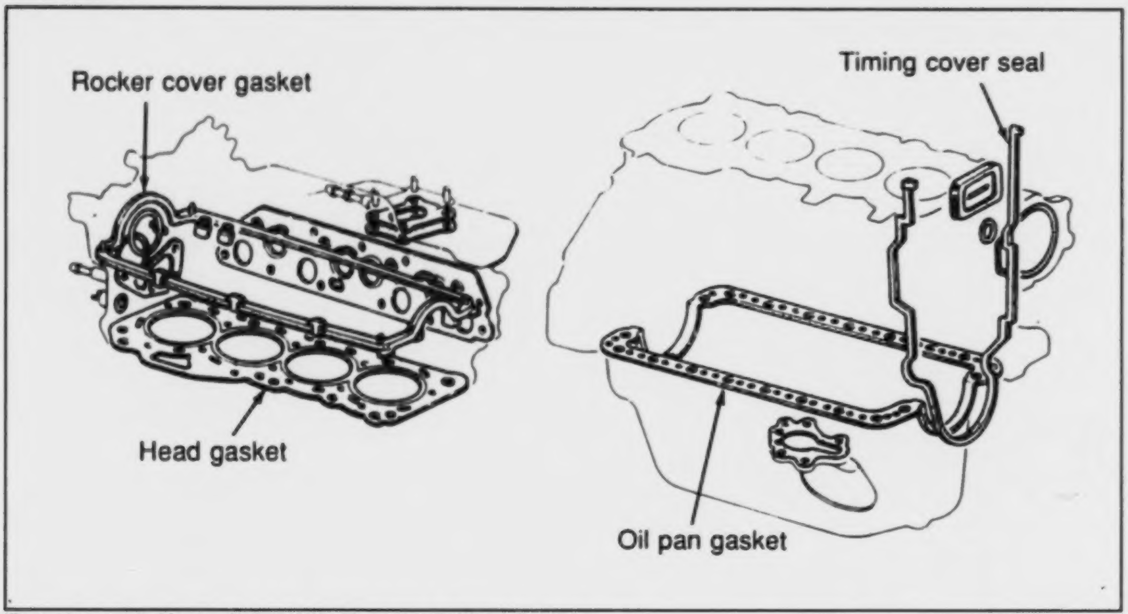

Illustration used with permission of American Honda Motor Co., Inc.

Yes No

19. Check the top surfaces of the engine for oil seepage. ____ ____

☑ **NOTE:** Seepage at this location is usually caused by a leaking gasket. The gasket will have to be replaced.

20. Start the engine and let the engine idle until the temperature gauge moves into the normal range. ____ ____

⚠ **DANGER:** UNVENTED EXHAUST FUMES in a closed building can cause death. ALWAYS CONNECT THE VEHICLE'S EXHAUST TO A VENT HOSE WHEN YOU RUN AN ENGINE IN A CLOSED SHOP.

---

21. Repeat steps 6 through 19 while the engine is idling. ____ ____

⚠ **WARNING:** LOOSE CLOTHING, HAIR, OR JEWELRY can be caught in moving parts while the engine is running. KEEP CLEAR OF MOVING PARTS.

	Yes	No
22. Turn off the engine.	____	____
23. Lower the hood.	____	____
24. Raise the vehicle on a hoist or jack stands.	____	____
25. Check the oil drain plug for oil leaks. If found, tighten the plug or replace it as necessary.	____	____
26. Check the oil pan and gasket for evidence of oil leaks and/or road damage; replace these components if necessary.	____	____
27. Check the entire area underneath the car, including structural members and the exhaust system, for oil, coolant, or fuel leaks. Reinspect components and repair leaks as needed.	____	____
☑ **NOTE:** Liquids may travel along parts of the vehicle and appear some distance from the original leak.		
28. Consult Information Sheet, objective 20 for help in completing your diagnosis and identifying needed repairs.	____	____
29. Lower the vehicle.	____	____
30. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

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Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
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2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB
SHEET 6

EVALUATING ENGINE CONDITION

5

Name ______________________________

OBJECTIVE 25 **Perform engine vacuum tests.**

INTRODUCTION

Vacuum in the intake manifold is created when pistons are moving down the cylinder, and the intake valves are open. Vacuum readings taken at the intake manifold can be very helpful in diagnosing several internal as well as external problems. Many functions of an engine are controlled by vacuum. If vacuum readings are abnormal, mechanical and electronic engine sensors will not function properly, causing poor performance. This is a common problem. A vacuum test should always be made when diagnosing engine condition, regardless of symptoms.

Connecting the Vacuum Gauge

To measure intake manifold vacuum, a vacuum gauge is connected to a tap on the intake manifold. There are ordinarily several taps and a number of hoses on the intake manifold. Locating the correct tap to make this connection can be difficult. The correct tap to use depends on the make and model of the vehicle being tested.

It is very important to connect the vacuum gauge to the correct tap. The vacuum reading will not read the same at every manifold tap. The service manual may tell you which tap you should use, but very often they don't. Experienced technicians often rely on other technicians who are familiar with the type of vehicle being tested. Your instructor will be able to tell you which taps to use on the vehicles in your shop.

If these methods fail, one way to locate the correct tap and get a correct vacuum reading is to measure the vacuum at all the taps and hoses. The tap with the highest reading is the most accurate. Obviously, using this method is time-consuming. One pitfall can be avoided by watching for any change in the way the engine runs (it may speed up or slow down) when you connect a gauge at a tap. If there is any change in the way the engine runs, you've tapped into the wrong location.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Handout 2, Interpret Engine Vacuum Readings
- Vacuum gauge with fittings
- Remote starter switch
- Pencil and paper
- Clock or watch
- Basic hand tool set

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references
- Use in-book reference tools

Functional Reading
- Interpret graphics and symbols

Math Application
- Use English and metric measures

Data Analysis and Display
- Collect/record data

Functional Math
- Make measurements

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

1. Raise the hood. ____ ____
2. Start the engine and let the engine idle until the temperature gauge moves into the normal range. ____ ____

⚠ **DANGER:** UNVENTED EXHAUST FUMES in a closed building can cause death. ALWAYS CONNECT THE VEHICLE'S EXHAUST TO A VENT HOSE WHEN YOU RUN AN ENGINE IN A CLOSED SHOP.

---

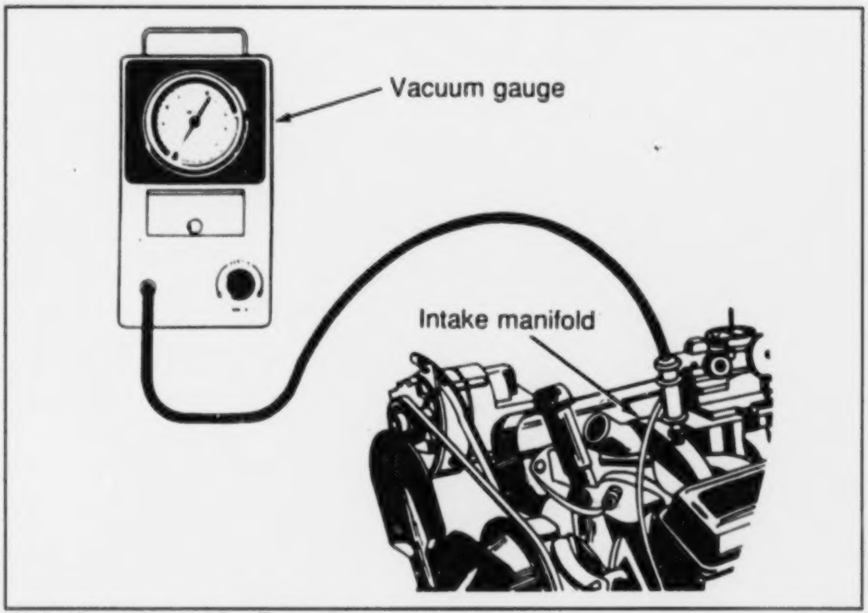
3. Turn off the engine. ____ ____
4. Connect a remote starter switch to the engine. ____ ____

   ☑ **NOTE:** Remote starter switches connect to different vehicles different ways. If you don't know how to connect a remote starter switch to the vehicle you are working on, have your instructor show you how.

5. Remove the intake manifold port vacuum line and connect the vacuum gauge T between the vacuum line and the manifold port. (Figure 1) ____ ____

   ☑ **NOTE:** Check the service manual for the proper location.

FIGURE 1



Used with permission of Sun Electric Corp.

Yes No

6. Look at the vacuum gauge dial as you use the remote starter switch to crank the engine until a good vacuum reading can be obtained. ____ ____

⚠ **NOTICE:** CRANKING THE ENGINE FOR MORE THAN 10 SECONDS may result in damage to the starter. CRANK THE ENGINE FOR ONLY 10 SECONDS AT A TIME.

7. Record the highest vacuum reading obtained during the 10 second crank. ____ ____

8. Wait 1-2 minutes for the starter to cool, then repeat steps 6 and 7 to check the reading. ____ ____

9. Refer to the vehicle's service manual to locate the vacuum reading which is appropriate during cranking. ____ ____

   ☑ **NOTE:** The normal vacuum reading during cranking will vary with the vehicle. Usually it is in the 10-16 in. Hg range and steady.

10. Use the remote starter switch to start the engine. ____ ____

	Yes	No
11. Read the vacuum gauge while the engine is idling.		
12. Record the vacuum reading.		
13. Refer to the vehicle's service manual to locate the vacuum reading which is appropriate during idling.		
☑ **NOTE:** The normal vacuum readings during idling will vary with the vehicle. Usually it is around 17 in. Hg and steady.		
14. If either the cranking or the idling vacuum reading is outside specifications, use Handout 2, Interpreting Engine Vacuum Readings, to help you diagnose the inappropriate reading.		
15. While looking at the vacuum gauge, rev the engine and hold the number of rpms steady for a few seconds.		
☑ **NOTE:** This can be done without using a tachometer if you simply hold your foot steady on the accelerator.		
16. If the gauge shows a gradual drop in pressure, the engine may have a restriction in the exhaust system. Diagnostic tests on the exhaust system will uncover the problem. (See Unit 4, *Servicing Exhaust Systems.*)		
☑ **NOTE:** The condition caused by a restriction in the exhaust system is also known as excessive *backpressure*.		
17. Turn off the engine.		
18. Remove the vacuum gauge from the intake manifold.		
19. Disconnect the remote starter switch.		
20. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.		

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

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Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 7

EVALUATING ENGINE CONDITION

5

Name ______________________________

OBJECTIVE 27

Perform a cylinder power balance test.

INTRODUCTION

When an engine is running smoothly, the work is evenly distributed among the cylinders. When one or more of the cylinders fails to do its equal share, the engine runs roughly, vibrates, and generally performs poorly. The cylinder power balance test will tell you which cylinder or cylinders are not doing their share of the work. However, on some vehicles, it is not possible to do a cylinder balance test. Consult your vehicle service manual and use the cylinder compression test instead.

In a cylinder power balance test, the technician uses an engine computer analyzer to interrupt the ignition spark in each cylinder one at a time. This interruption of the ignition spark is a procedure known as *shorting out.* The resulting loss in rpm and drop in vacuum is noted for each cylinder. If the power loss for the engine is about the same when each cylinder is shorted out, then all cylinders are working equally. There should be at least a 5% power loss when a cylinder is shorted out. The cylinders should also be working within 5% efficiency of each other. If there is more than a 5% difference between the cylinder with the highest reading and the cylinder with the lowest reading, then an engine problem is indicated.

A cylinder power balance test will not tell you why the cylinders are producing power at different rates. Some of the many possible reasons are:

Problems inside the engine:

- Burned valves
- Worn pistons
- Leaking head gasket

Problems outside the engine:

- Vacuum leak
- Misadjusted carburetor
- Faulty fuel injector
- Ignition malfunction
- Computer sensor malfunction

Engine tests covered in other Job Sheets in this unit must be made to make a more detailed diagnosis.

EQUIPMENT AND SUPPLIES

- Vehicle with a computer-controlled engine
- Appropriate service manual
- Engine analyzer with manual
- Pencil and paper
- Basic hand tool set

The procedure given is only for engines that are computer-controlled. Make sure your instructor has trained you in the use of the engine analyzer you will be using to make this test.

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Data Analysis and Display
- Collect/record data

Functional Math
- Make measurements

General Science
- Use scientific instruments
- Investigate/apply technology

Physical Science
- Investigate/apply physical laws

Cognitive Activities
- Transfer knowledge/training to new situations

	Yes	No
1. Place vehicles with automatic transmission in park and manual transmissions in neutral.	____	____
2. Raise the hood	____	____
3. Hook up the engine analyzer.	____	____
4. Start the engine and let the engine idle until the temperature gauge moves into the normal range.	____	____

⚠ **NOTICE: DANGER:** UNVENTED EXHAUST FUMES in a closed building can cause death. ALWAYS CONNECT THE VEHICLE'S EXHAUST TO A VENT HOSE WHEN YOU RUN AN ENGINE IN A CLOSED SHOP.

	Yes	No
5. Use the engine analyzer to short out the cylinders one at a time.	____	____

⚠ **NOTICE:** OVERHEATING AND DAMAGE TO THE CATALYTIC CONVERTER can occur if you leave any one cylinder shorted out for more than 10 seconds. DO NOT SHORT OUT ANY CYLINDER FOR MORE THAN 10 SECONDS.

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

	Yes	No
6. Record the vacuum and rpm reading as each cylinder is shorted out.	____	____
7. Turn off the engine.	____	____
8. Review your findings	____	____

☑ **NOTE:** A cylinder problem is indicated if: (1) The vacuum/ rpm reading does not drop at least 5% when any one cylinder is shorted out. (2) The difference between the highest reading recorded for a cylinder and the lowest reading recorded for a cylinder is more than 5%.

9. Disconnect the engine analyzer.	____	____
10. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1

Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 8 EVALUATING ENGINE CONDITION

Name ____

OBJECTIVE 28 **Calibrate an exhaust gas analyzer, test a vehicle's exhaust, and obtain exhaust gas readings.**

WORDS YOU SHOULD KNOW	
(CO)	carbon monoxide
(CO_2)	carbon dioxide
(HC)	hydrocarbons
(NO_x)	oxides of nitrogen
(O_2)	oxygen
ppm	parts per million

INTRODUCTION

Engine exhaust gases contain chemical substances that change with combustion efficiency. By measuring these substances, the engine's emission systems can be tested for proper working order and effective emission control. An exhaust gas analyzer measures the chemical content of the engine's exhaust. Calibrating the meters typically means adjusting the needles of a warmed analyzer to zero while sampling clean air. Be sure not to have any exhaust gases in the room. Always refer to the manufacturer's guidelines when calibrating the exhaust gas analyzer.

☑ **NOTE:** A four-gas exhaust analyzer also measures carbon dioxide (CO_2) in percent by volume.

Guidelines:

- An analyzer reading of 100 ppm HC means there are 100 parts of HC for every million parts of exhaust gas. A newer car, having stricter requirements, could have a 100 ppm HC spec. If HC is higher, the car's HC emissions or unburned fuel is too high. An adjustment or repair would be required.

- An analyzer reading of one percent of CO would mean that one percent of the engine exhaust is made up of CO. High CO is basically caused by incomplete burning and a lack of air during combustion. If the reading is higher than manufacturer specifications, locate and correct the cause of the problem

- O_2 readings should be between 1 and 7 per cent. O_2 is needed for the catalytic converter to burn HC and CO emissions. O_2 readings are used to check the operation of the carburetor, fuel injection system, catalytic converter, and control computer. Oxygen in the exhaust is an accurate indicator of a lean air-fuel mixture.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Use content area vocabulary

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1

Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

General Science
- Use scientific instruments
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

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____

____

Engine Performance Specialist

Student Workbook

Part 2

Developed by the
Curriculum and Instructional Materials Center
for the Division of **Trade and Industrial Education**
Oklahoma Department of Vocational and Technical Education

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Curriculum and Instructional Materials Center

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Unit 2
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Unit 3
Servicing Engine Cooling Systems 3-1

Unit 4
Servicing Exhaust Systems 4-1

Unit 5
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Part 2

Unit 6
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OBJECTIVE SHEET

UNDERSTANDING ENGINE COMPUTER CONTROLS

6

INTRODUCTION

Most vehicles now have computer control systems which may control such things as engine systems, air conditioning, automatic transmissions, antilock brakes, and electronic leveling. The use of computers allows the vehicle to achieve greatly improved results in terms of safety, performance, fuel economy, efficiency, and emission control. Computer control systems have been built into most imports since the 1960s, and most domestic vehicles have included them since the early 1980s.

Engine Performance Technicians use the engine computer to help them diagnose problems in any of the systems that affect engine condition and operation.

PREREQUISITE

Unit 5, "Evaluating Engine Condition"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS	
PREREADING:	Read Paul Weissler's article, "Inside the '91s," from *Popular Mechanics* magazine, October 1990, pp. 32-35. As you read, consider what technological advances manufacturers have made in computerizing various automotive systems and how those advances have improved the vehicles.
WRITING:	Write a short (one paragraph to one page) explanation of how manufacturers have improved engine performance through the use of computers and what you think the reaction is from consumers to these changes.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Job Sheet and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. Describe the functions of the three main components of engine computer control systems.
2. Match the names of common sensors to the function monitored by the sensor.
3. Match the names of common sensors to illustrations of the sensors.
4. Match the names of common control devices to the engine functions they control.
5. Match the names of common control devices to illustrations of the devices.
6. List information that can be monitored by an engine computer analyzer.
7. Name types of engine computer analyzers shown in illustrations.
8. Compare and contrast engine computer analyzers and scan tools.
9. Hook up an engine computer analyzer and a scan tool. (Job Sheet)

INFORMATION SHEET

UNDERSTANDING ENGINE COMPUTER CONTROLS

6

OBJECTIVE 1

Required Activities/ Resources
- Examples of components
- Vehicle with an engine computer
- Handout

Optional Activities/ Resources in Instructor's Guide

Describe the functions of the three main components of engine computer control systems.

Examine examples of a sensor, an engine computer, and a control device as your instructor explains how these components work together.

Look at the components of an engine computer control system as your instructor points them out on an actual vehicle.

Read the Handout to help you understand engine computer control systems.

- **sensors** – provide information to the engine computer
- **engine computer** – analyzes the information, decides what changes to make, if any, and signals the control devices

  NOTE: Engine computers usually have a self-diagnostic capability. If a malfunction occurs in any engine system, the memory stores the information, even if the malfunction later disappears. When recalled from memory at a later time, this stored information may help the technician diagnose and repair the problem. Most engine computers maintain this malfunction memory until the vehicle has been restarted fifty times without a reoccurrence of the malfunction. After that, memory of the malfunction is automatically erased.

- **control devices** – carry out actions as directed by the engine computer to control engine systems

  EXAMPLE:

  Input → Engine Computer → Output
  (Sensors) (Control devices)

  NOTE: The sensors constantly monitor a variety of operating conditions which affect engine operation and send this information to the engine computer. The engine computer uses this information to make decisions regarding the adjustments that should be made to the engine in order to achieve the best results in terms of safety, performance, fuel economy, efficiency, and emission control. When the engine computer determines that such adjustments are needed, it sends a signal, or several signals, to the appropriate control devices which make the requested adjustments to the engine systems involved.

OBJECTIVE 2

Required Activities/
Resources
– Sensors

Optional Activities/
Resources in
Instructor's Guide

Match the names of common sensors to the function monitored by the sensor.

Examine different types of sensors on display in the classroom.

☑ **NOTE:** See the information in objective 3.

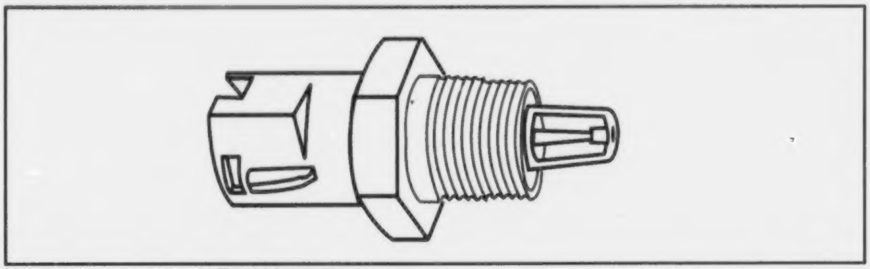
OBJECTIVE 3

Match the names of common sensors to illustrations of the sensors.

- **air charge sensor (ACS)** — measures the temperature of the air entering the engine for combustion

☑ **NOTE:** The air charge sensor is sometimes called the *air charge temperature sensor (ACT).*

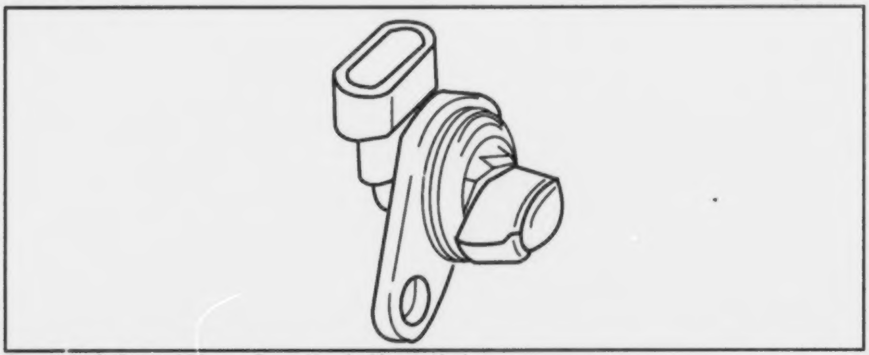
FIGURE 1



Used with permission of Ford Motor Co.

- **camshaft position sensor** — reports camshaft and valve position of the #1 piston

FIGURE 2



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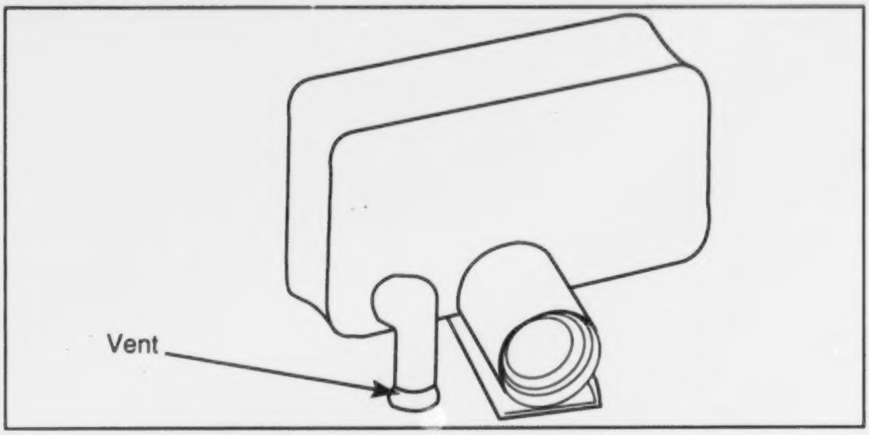
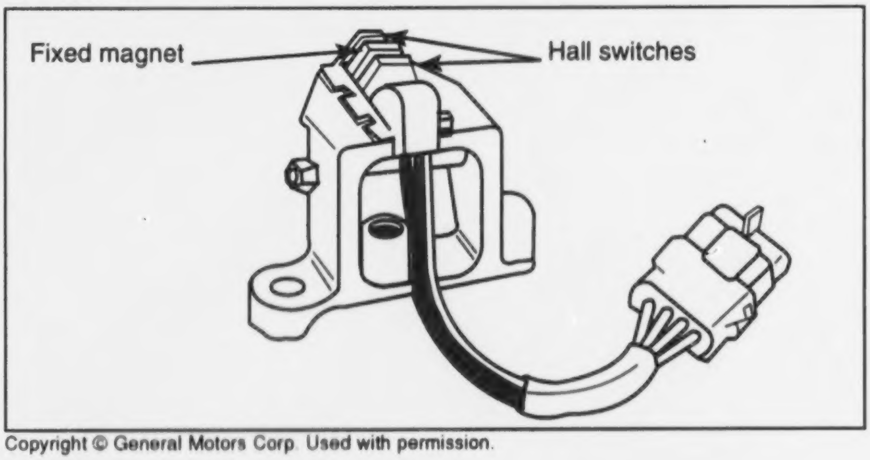
- **barometric pressure sensor (BAP)** — measures barometric pressure

FIGURE 3



- **crankshaft position sensor** — reports engine speed and the position of the #1 piston

FIGURE 4



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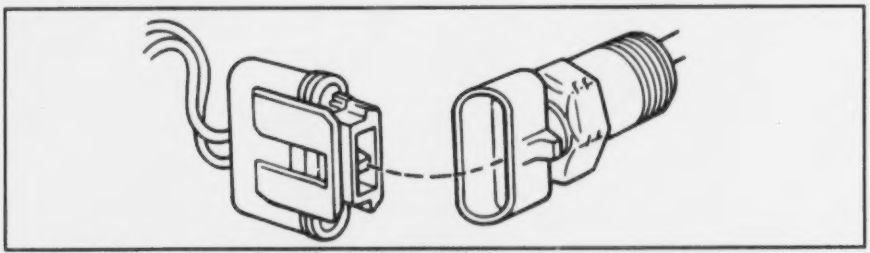
- **coolant temperature sensor (CTS)** — measures the temperature of the coolant

FIGURE 5



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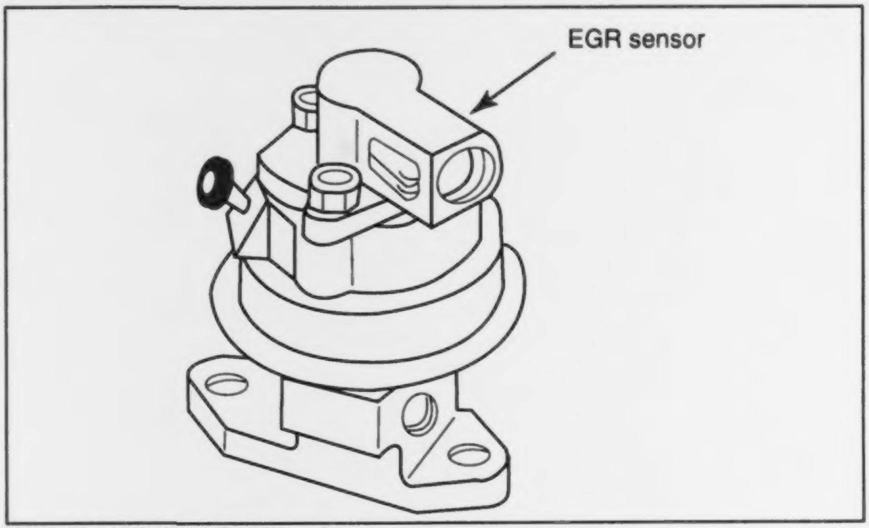
- **distributor reference sensor** — reports engine speed (rpm)

  ☑ **NOTE:** The *distributor reference sensor* is an internal part of the ignition control module.

- **exhaust gas recirculation (EGR) sensor (EVP)** — monitors the position of the EGR valves

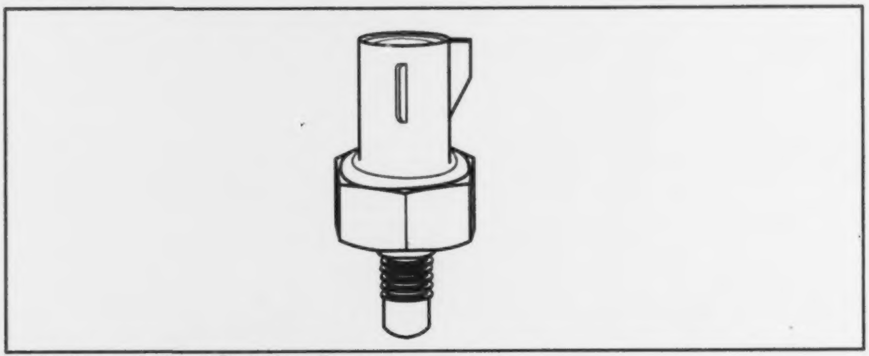
FIGURE 6



Used with permission of Ford Motor Co.

- **knock sensor** — reports vibrations in the engine

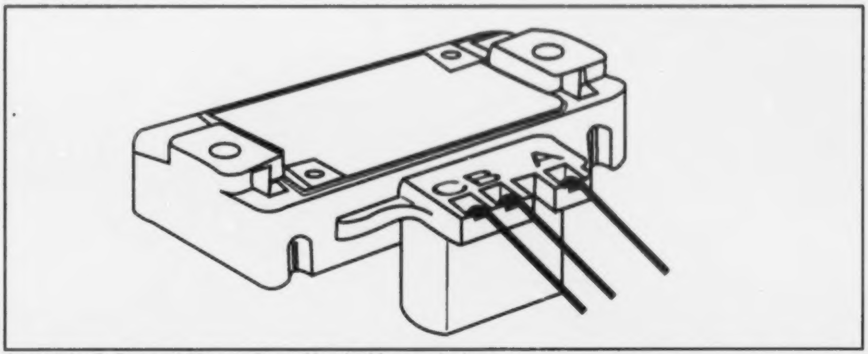
FIGURE 7



Used with permission of Ford Motor Co.

- **manifold absolute pressure (MAP) sensor** — measures the pressure inside the intake manifold

FIGURE 8



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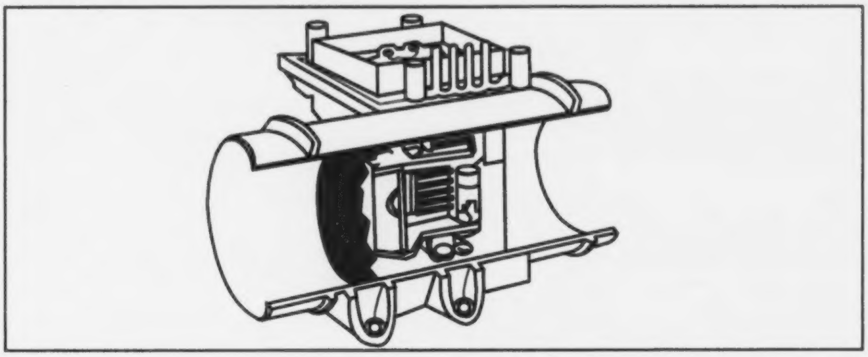
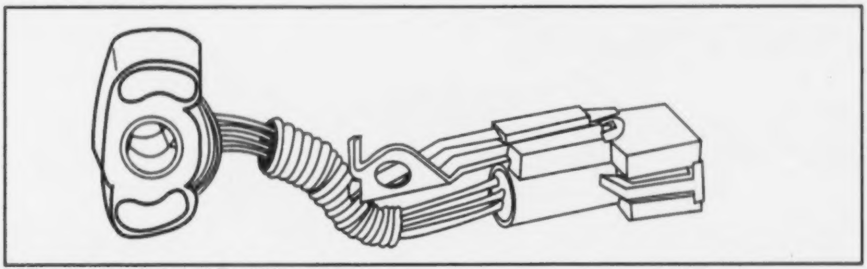
- **mass air flow (MAF) sensor** — measures the amount of outside air flowing into the intake manifold

FIGURE 9



- **throttle position sensor (TPS)** — monitors the position of the gas pedal

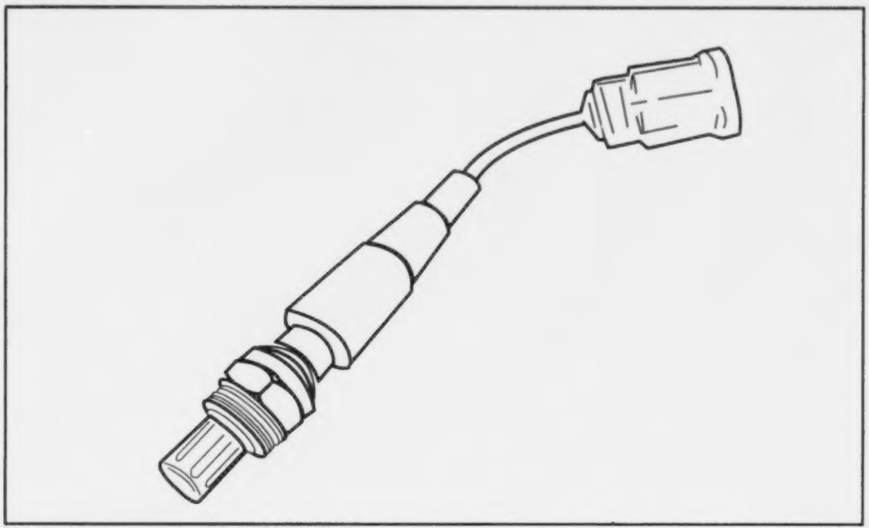
FIGURE 10



Used with permission of Ford Motor Co.

- **oxygen (O_2) sensor** — monitors the oxygen content of exhaust gases

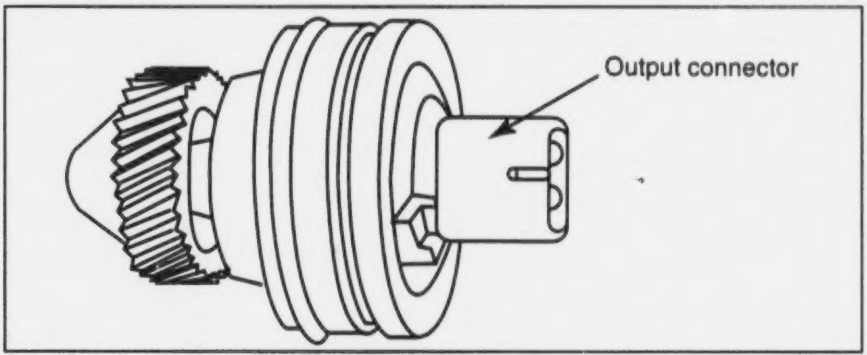
FIGURE 11



Used with permission of Ford Motor Co.

- **vehicle speed sensor (VSS)** — reports how fast the vehicle is moving

FIGURE 12



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OBJECTIVE 4

Required Activities/
Resources
– Control devices

Optional Activities/
Resources in
Instructor's Guide

Match the names of common control devices to the functions they control

Examine different types of control devices on display in the classroom.

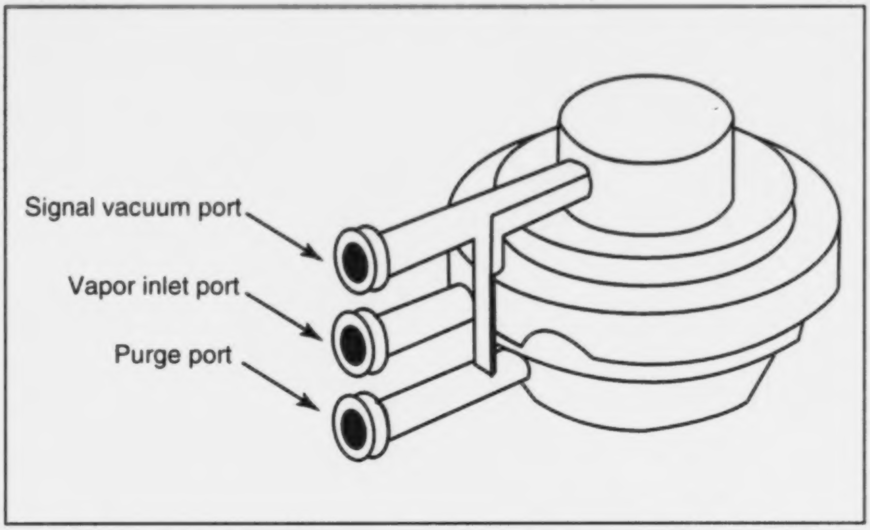
NOTE: See the information in objective 5.

OBJECTIVE 5

Match the names of common control devices to illustrations of the devices.

- **carbon canister purge valve** — releases fuel vapors to the intake manifold when a richer air-fuel mixture is required

FIGURE 13

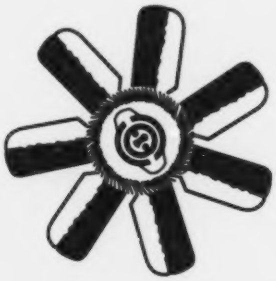


- **electronic spark timing module (DIS)** — adjusts ignition timing

  ☑ **NOTE:** The *electronic spark timing device* is usually an internal part of the ignition control module.

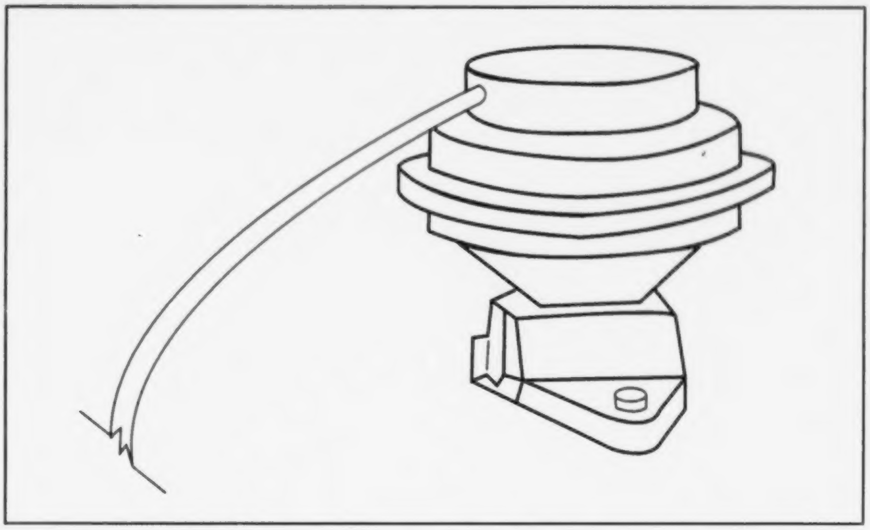
- **engine cooling fan** — cools the radiator when the coolant is too hot

FIGURE 14



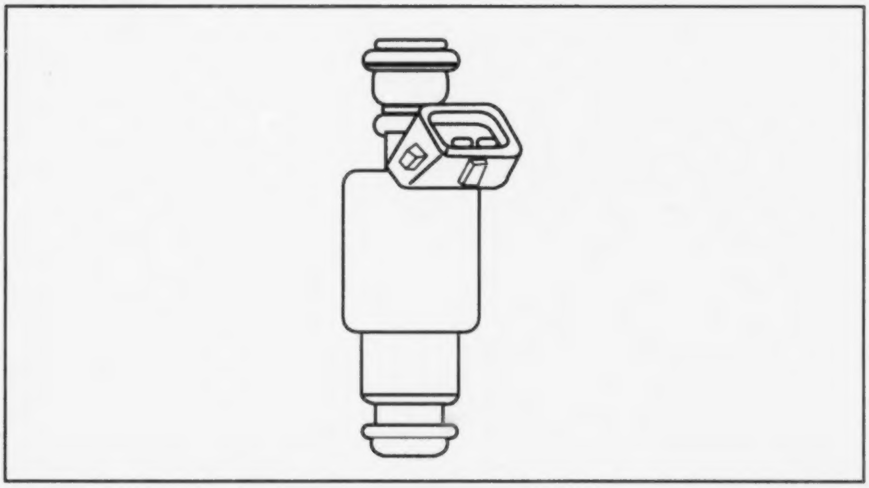
- **exhaust gas recirculation valve** — allows a controlled amount of exhaust gas to return to the intake manifold, thereby reducing combustion temperature and therefore emissions

FIGURE 15



- **fuel injector** — controls the amount of fuel entering the engine

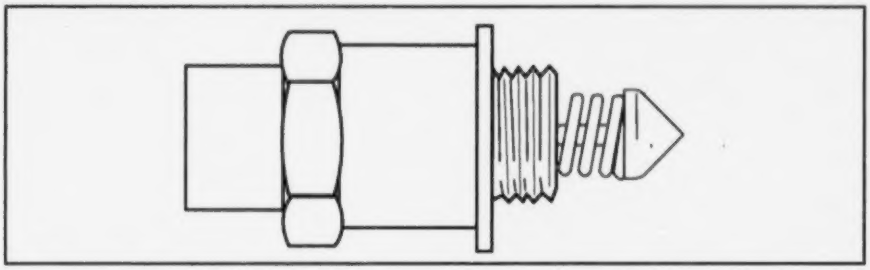
FIGURE 16



- **idle air control valve** — adjusts air flow to increase engine idle speed

  ☑ **NOTE:** Some conditions which require an increased idle speed are: during some steering conditions, deceleration, gear changes, and air conditioner operation.

FIGURE 17



OBJECTIVE 6

List information that can be monitored by an engine computer analyzer.

- operating condition of the engine systems
- ignition system operations
- engine temperature
- engine speed
- makeup of the engine exhaust
- engine vacuum available to engine vacuum-operated devices
- fuel pressure
- electrical information

☑ **NOTE:** Electrical information includes voltage resistance, amps, and the condition of the electrical circuits.

OBJECTIVE 7

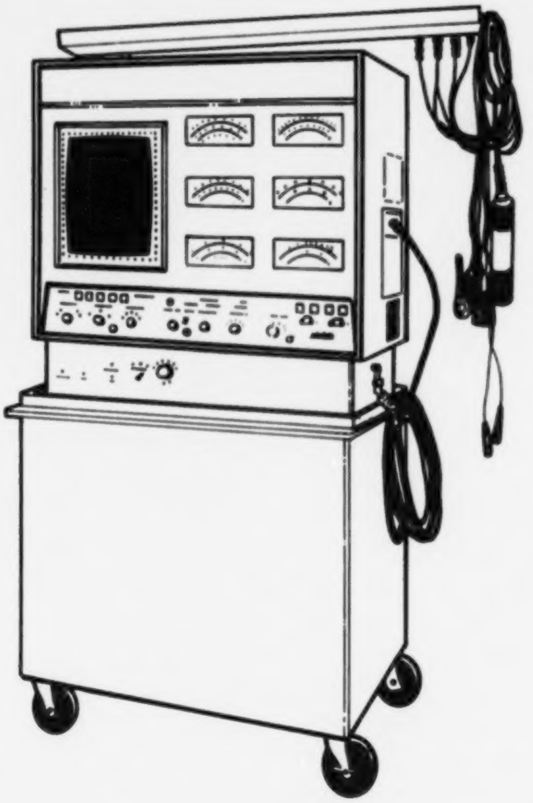
Required Activities/
Resources
– Engine computer analyzer and a scan tool

Name types of engine computer analyzers shown in illustrations.

☞ Examine an actual engine computer analyzer and a scan tool.

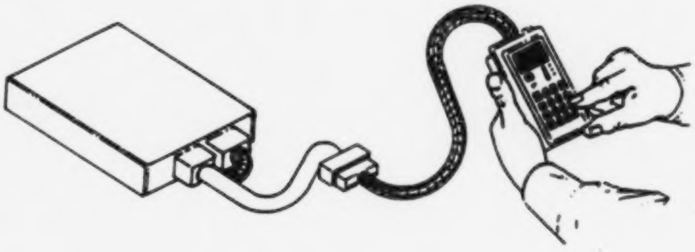
- **engine computer analyzer**

FIGURE 18



- **scan tool**

FIGURE 19



Used with permission of OTC Tool & Equipment Division of SPX Corp.

OBJECTIVE 8 **Compare and contrast engine computer analyzers and scan tools.**

Required Activities/
Resources
– Transparency Masters
1 and 2

Look at transparencies 10 and 11 as your instructor compares the operation of each type of engine computer analyzer.

FEATURE	ENGINE COMPUTER ANALYZERS	SCAN TOOLS
Engine hook-ups	Multiple hook-ups	Usually a single hook-up
Data monitored	Variety of data monitored other than just the engine computer	Usually monitors engine computer information only
Size	Mounted in a roll-around cabinet or can be portable	Hand-held
Decision making ability	Able to draw conclusions from the data monitored (It has diagnostic charts and test procedures stored in its memory.)	Able to draw conclusions from the data monitored (It has diagnostic charts and test procedures stored in its memory.)
Type of power	AC-powered	Battery-powered
Paper printout	Produces a paper printout of test results and diagnosis	Usually requires a separate printer to provide a paper printout
Display window	Contains a full screen of information	Contains a full screen of information
Use while test driving vehicle	Can be used while test driving the vehicle only if the unit is portable	Can be used while test driving the vehicle
Ability to update information	Can be updated with new software	Can be updated with new software
Price	$8,000 +	$400 to $1,000
Available with an exhaust gas analyzer	Yes	Yes

OBJECTIVE 9 **Complete the Job Sheet.**

JOB SHEET

UNDERSTANDING ENGINE COMPUTER CONTROLS

6

Name ______________________________

OBJECTIVE 9

Hook up an engine computer analyzer and a scan tool.

Required Activities/ Resources
- Explanation
- Demonstration

Listen as your instructor explains what engine problems can be diagnosed with a scan tool and an engine computer analyzer.

Watch as your instructor demonstrates how improper hook-up can lead to inaccurate or no results on tests that are performed.

INTRODUCTION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Use scientific instruments
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Both the hand-held scan tool and the larger engine computer analyzer are hooked up to the engine computer's diagnostic connector. This connector is not located on the engine computer itself, but at another location, for example, under the dash, under the hood, or under a seat. An appropriate service manual will tell you the location of the diagnostic connector on the vehicle you are testing.

For a scan tool, the hookup to the diagnostic connector is the only hookup that can be made. However, an engine computer analyzer will direct you to other hookups, such as —at the spark plugs, —to a vacuum line, —to an exhaust tube, —to the coil, and so forth. These hookup points will not be special hookups designed just for vehicles with engine computers; they are all points where routing engine system tests can be made even on vehicles without an engine computer. If you only hooked up an engine computer analyzer at the diagnostic connector, it would only give you the identical information that a scan tool can give you, but if you also hook it up to the additional testing positions, much more information can be obtained and the engine analyzer's diagnostic capability can operate.

The number and type of hookups for an engine computer analyzer vary with the type of analyzer. Sometimes optional adapters may even be required to use the analyzer with certain vehicles. An operation manual for the analyzer is vital to its proper use. With either an engine computer analyzer or a scan tool, you must enter the vehicle identification number (VIN), the production date, make and model before you can monitor information. It is best to get this information before you begin your hookup.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Engine analyzer and operation manual
- Scan tool and operation manual
- Other equipment and supplies as required by the procedure

PROCEDURE

	Yes	No
Refer to the appropriate equipment operation manuals for the scan tool and the engine computer analyzer.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

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OBJECTIVE SHEET

SERVICING IGNITION SYSTEMS

7

INTRODUCTION

Vehicles need an electrical spark to ignite the compressed air-fuel mixture for the engine to start. This process is called ignition. An ignition system operates by increasing the battery voltage to a much higher voltage at the spark plugs, then igniting the fuel mixture at precisely the right time to fire the compressed air-fuel mixture. In this unit, you will learn how to diagnose and adjust the ignition system on older vehicles and on newer, more complex vehicles as well.

PREREQUISITE

Unit 6, "Understanding Engine Computer Controls"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS	
PREREADING:	Read about a distributorless ignition system, in Don Chaiken's article, "Distributorless Ignition — How It Works," in *Popular Mechanics* magazine, June 1992, p. 90. Pay special attention to how this ignition system operates without a distributor and why this is considered an improvement over ignition systems that use a distributor.
WRITING:	Write a short (one page) step-by-step outline of how a distributorless ignition system works, specifically including the way it operates without a distributor. Also, include the reason why distributorless ignition systems are considered an improvement over ignition systems that use a distributor.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment Sheet and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. State the purpose of an automotive ignition system.
2. Identify three types of ignition systems shown in illustrations.

3. Label ignition system components indicated on illustrations of the three types.
4. Match the names of ignition system components to descriptions of their functions.
5. Describe the operation of an electronic distributor ignition system.
6. Describe the operation of an electronic distributorless ignition system.
7. Compare and contrast types of ignition systems.
8. State the purpose of a triggering system.
9. Match the names of types of triggering systems for electronic ignition systems to descriptions of their operation.
10. State the purpose of an ignition coil.
11. State the main difference between the primary circuit and the secondary circuit.
12. Distinguish between primary and secondary circuit components on an illustration.
13. Match the names of the parts of an ignition coil to an illustration.
14. Match the names of the parts of a distributor to an illustration.
15. Label the parts of a spark plug indicated on an illustration.
16. Match the names of types of spark plugs to statements describing their qualities.
17. Match the names of secondary pattern oscilloscope tests to the ignition system condition or function monitored by the test.
18. Identify abnormal oscilloscope patterns shown in illustrations.
19. Draw a typical primary oscilloscope pattern for an electronic distributor ignition.
20. Draw a typical primary oscilloscope pattern for a contact point ignition.

21. Circle the area of an oscilloscope pattern which corresponds to ignition coil ON.

22. Circle the area of an oscilloscope pattern which corresponds to ignition coil OFF.

23. Inspect, test, repair, and replace the ignition primary circuit wiring and components. (Job Sheet 1)

24. Inspect, test, adjust, service, repair, and replace the ignition points and condenser. (Job Sheet 2)

25. Inspect, test, service, repair, and replace the ignition system secondary circuit wiring and components. (Job Sheet 3)

26. Inspect, test, and replace ignition coils. (Job Sheet 4)

27. Inspect, test, and replace an electronic ignition wiring harness and connectors. (Job Sheet 5)

28. Inspect, test, and replace electronic ignition system pick-up sensors or triggering devices. (Job Sheet 6)

29. State the purpose of a spark timing system.

30. Match the names of types of spark timing systems to descriptions of their operation.

31. Match the names of types of ignition systems to the names of the spark timing systems used with them.

32. Test and adjust spark timing systems. (Job Sheet 7)

33. Inspect, test, repair, and replace the components of a spark timing system. (Job Sheet 8)

34. Inspect, test, repair, and replace electrical/electronic components and circuits of a spark timing system. (Job Sheet 9)

35. Inspect, test, and service a distributor. (Job Sheet 10)

36. Inspect, test, and replace an electronic ignition system control unit. (Job Sheet 11)

37. Diagnose no-starting, engine misfire, poor driveability, spark knock, power loss, and poor mileage problems. (Assignment Sheet)

INFORMATION SHEET

SERVICING IGNITION SYSTEMS

7

OBJECTIVE 1

State the purpose of an automotive ignition system.

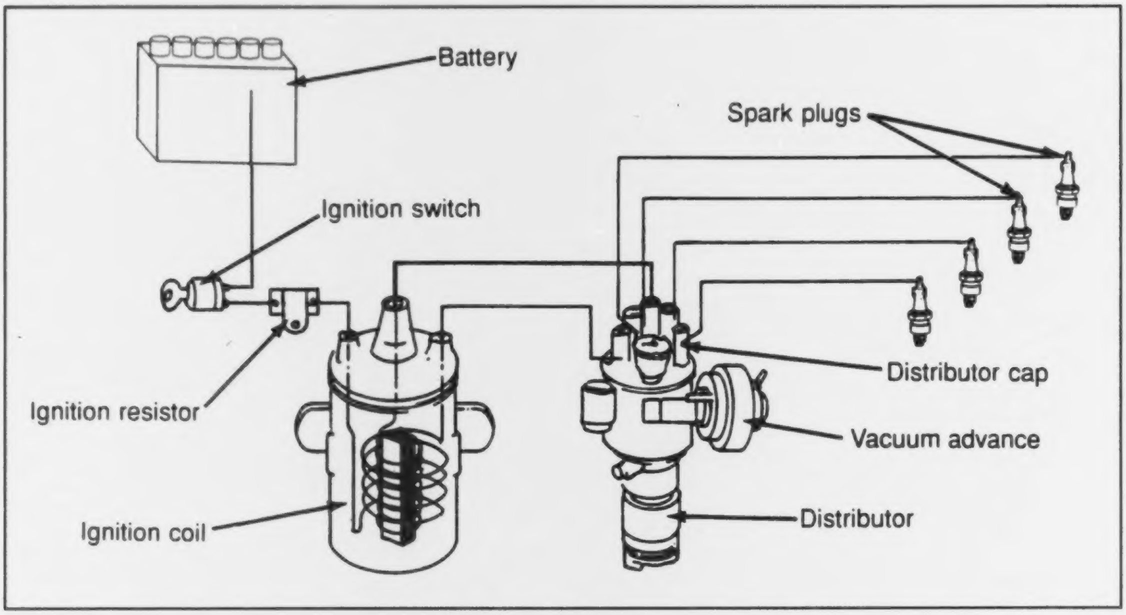
The purpose of an automotive ignition system is to ignite the air-fuel mixture in the engine cylinders.

OBJECTIVE 2

Identify three types of ignition systems shown in illustrations.

- **Contact point ignition system**

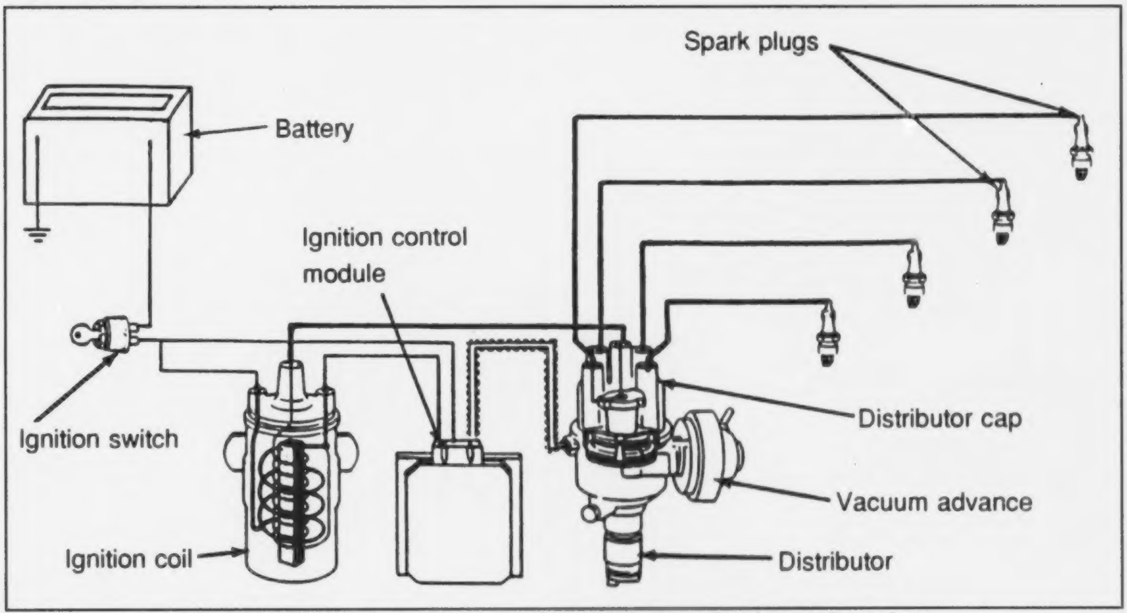
FIGURE 1


Battery
Spark plugs
Ignition switch
Ignition resistor
Distributor cap
Vacuum advance
Ignition coil
Distributor

☑ **NOTE:** ***Contact point ignition systems*** regulate spark timing by using contact points to make and break an electric current. Although this type of system has not been installed in new automobiles for many years, it is important to understand the contact point ignition system because many older models which have it are still in use.

- **Electronic distributor ignition system**

FIGURE 2


Spark plugs
Battery
Ignition control module
Ignition switch
Distributor cap
Vacuum advance
Ignition coil
Distributor

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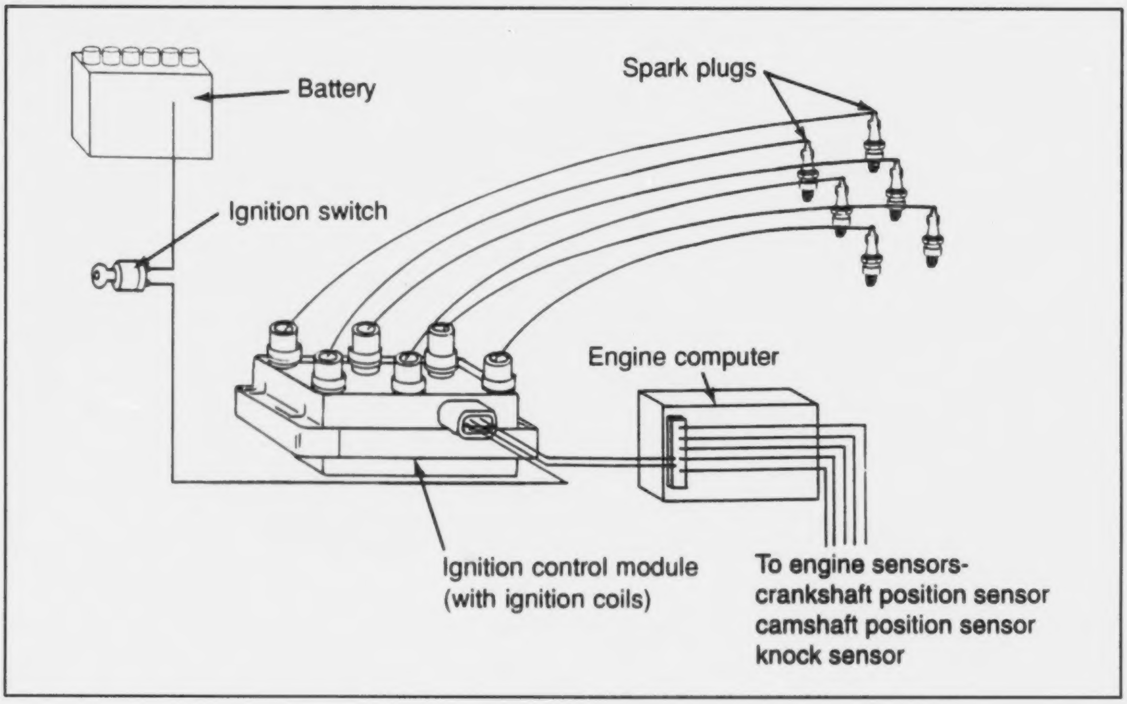
☑ **NOTE:** ***Electronic distributor ignition systems*** regulate spark timing by using an ignition control module instead of contact points to open and close the primary circuit. Electronic ignition systems are the most common system in use today.

- **Electronic distributorless ignition system**

FIGURE 3


Spark plugs
Battery
Ignition switch
Engine computer
Ignition control module (with ignition coils)
To engine sensors-
crankshaft position sensor
camshaft position sensor
knock sensor

NOTE: Instead of using a distributor to control spark timing, ***electronic distributorless ignition systems*** use camshaft and crankshaft sensors to provide the electronic control unit with information on engine speed and piston position. The ignition control module uses multiple ignition coils to feed high voltage electricity to the spark plugs at the right time. Distributorless ignition systems are also called *waste spark* systems and *computer-coil* systems. This type of system is becoming more common in newer vehicles.

OBJECTIVE 3

Required Activities/ Resources
- Transparency Masters 1-3
- Vehicles with each type of ignition system

Label ignition system components indicated on illustrations of the three types.

Look at transparencies 1-3 illustrating the three different types of ignition systems and their components as your instructor explains how the components operate together.

Look at the components of each type of ignition system as your instructor shows them to you on actual vehicles.

NOTE: Refer to the ignition system components shown in Figures 1, 2, and 3 in objective 2.

OBJECTIVE 4

Required Activities/
Resources
– Ignition system
components

Match the names of ignition system components to descriptions of their functions.

Examine actual ignition system components as your instructor describes their functions.

- **battery** — provides electrical power for the vehicle
- **camshaft position sensor** — reports camshaft and valve position on the #1 piston
- **crankshaft position sensor** — reports engine speed and the position of the #1 piston
- **distributor** — determines the firing order of the cylinders and directs electrical power to the correct spark plug at exactly the right time
- **distributor cap** — its central terminal transfers electrical power from the coil wire to the rotor; its outer terminals receive current from the rotor and transfer it to the spark plug wires
- **engine computer** — analyzes information from engine sensors, decides what changes to make, if any, and signals the control devices
- **ignition coil** — increases the low voltage from the battery to the higher voltage required to create a spark at the spark plug
- **ignition control module** — an ignition system computer which receives information from various sources, analyzes that information, and uses it to ground the coils at the correct instant
- **ignition (ballast) resistor** — reduces the voltage from the battery

  ☑ **NOTE:** This voltage reduction keeps the contact points from burning and allows the ignition coil to run cooler.

- **ignition switch** — turns the ignition system on and off
- **knock sensor** — reports engine vibration indicating the need for less spark advance
- **spark plug** — uses electricity from the ignition coil to ignite the air-fuel mixture in the cylinder
- **vacuum advance** — advances spark timing

OBJECTIVE 5

Required Activities/
Resources

Describe the operation of an electronic distributor ignition system.

When the ignition switch is turned ON, transistors electronically cause the distributor to ground the ignition coil and begin the flow of high voltage electricity from the ignition coil through the distributor cap and rotor to the spark plug, igniting the air-fuel mixture in each cylinder. Electronic devices cause the distributor to continue to ground the coil at split second intervals, timing the sparks with valve operation.

OBJECTIVE 6

Describe the operation of an electronic distributorless ignition system.

When the ignition switch is turned ON, crank and/or cam sensors signal the position of the crankshaft to the engine computer to ground the ignition coil and begin the flow of voltage to the spark plug at each cylinder, creating a spark which ignites the air-fuel mixture in the cylinder and electronically time the sparks with valve operation.

OBJECTIVE 7

Required Activities/
Resources
– Explanation

Compare and contrast types of ignition systems.

Listen as your instructor explains the differences and similarities between the three types of ignition systems.

Similarities and Differences Between Ignition Systems

	Contact Point	Electronic Distributor	Electronic Distributorless
Number of coils	Single coil	Single coil	Multi-coil
Regulation of spark timing	Controlled by contact points	Controlled by computer	Controlled by computer
Maintenance	Regular maintenance of contact points	None required	None required
Firing order of cylinders	Determined by distributor	Determined by distributor	Determined by computer
Purpose	Ignite air-fuel mixture in the cylinders	Ignite air-fuel mixture in the cylinders	Ignite air-fuel mixture in the cylinders

OBJECTIVE 8

State the purpose of a triggering system.

The triggering system turns the flow of current to the ignition coil on and off.

OBJECTIVE 9

Required Activities/
Resources
– Types of triggering systems

Match the names of types of triggering systems for electronic ignition systems to descriptions of their operation.

☞ Examine types of triggering systems as your instructor identifies them and explains their operation.

- **magnetic pickup** — uses a coil magnetic type sensor to detect the rotation of a toothed wheel and sends a signal to the ignition control unit
- **Hall effect** — uses a semiconductor sensor to detect rotation of trigger blades or shutters and sends a signal to the ignition control unit

  ☑ **NOTE:** This is the most common type of triggering device.

- **photodiode** — senses the light flashes produced by a light-emitting diode and spinning trigger blades and sends a signal to the ignition control unit

  ☑ **NOTE:** All three types of electronic triggering devices can be used with either distributor or distributorless electronic ignition systems. In a contact point type ignition system, the triggering function is carried out by the contact points.

OBJECTIVE 10

State the purpose of an ignition coil.

The ignition coil increases the voltage of the vehicle's battery until it is great enough to ignite the air-fuel mixture in the engine cylinders.

OBJECTIVE 11

State the main difference between the primary circuit and the secondary circuit.

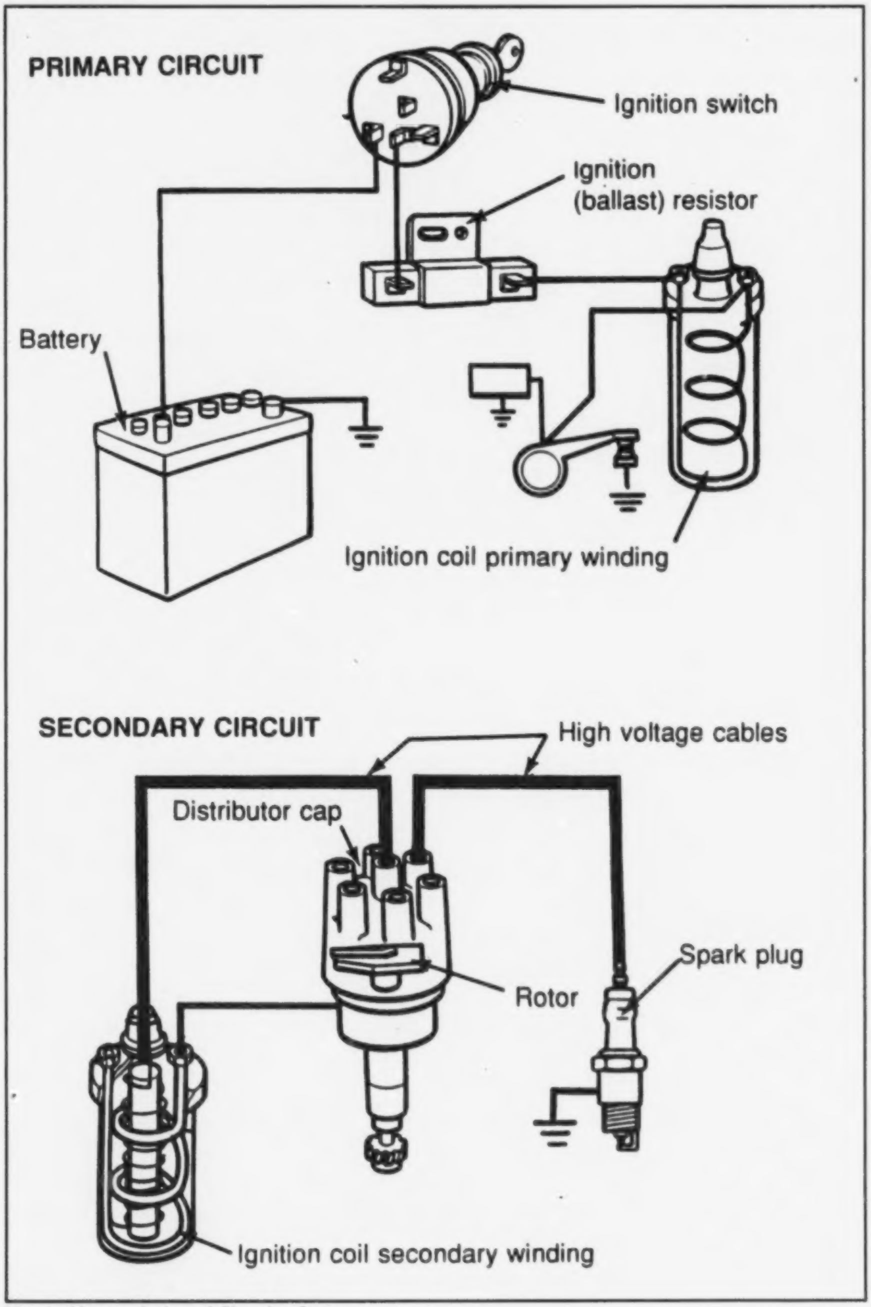
The electric current in the primary circuit is low voltage, and the current in the secondary circuit is high voltage.

☑ **NOTE:** The voltage of the electricity from the vehicle's battery is too weak to cause the spark needed for ignition. The power (voltage) of this electricity is increased by the wire coils inside the ignition coil. The voltage of the electricity as it leaves the ignition coil is considerably greater than the voltage of the electricity entering the coil. This difference in voltage is what defines the primary and secondary circuits.

OBJECTIVE 12

Distinguish between primary and secondary circuit components on an illustration.

FIGURE 4


PRIMARY CIRCUIT
Ignition switch
Ignition (ballast) resistor
Battery
Ignition coil primary winding
SECONDARY CIRCUIT
High voltage cables
Distributor cap
Spark plug
Rotor
Ignition coil secondary winding

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NOTE: The primary circuit is made up of those ignition system parts through which low voltage battery current flows. The primary circuit includes the circuit from the battery to the secondary windings in the ignition coil. Wiring used for the primary circuit is conventional wire like that used in other electrical systems in the vehicle. The ignition system's secondary circuit is made up of those parts through which the high voltage from the ignition coil flows. The secondary circuit includes the circuit from the coil tower of the ignition coil to the spark plugs. Both low voltage and high voltage are carried inside the ignition coil. The wiring used in the secondary circuit has thicker insulation to prevent leakage of the high voltage electricity. Because high voltage current is dangerous, be sure to follow all safety precautions when working with parts of the secondary circuit.

OBJECTIVE 13

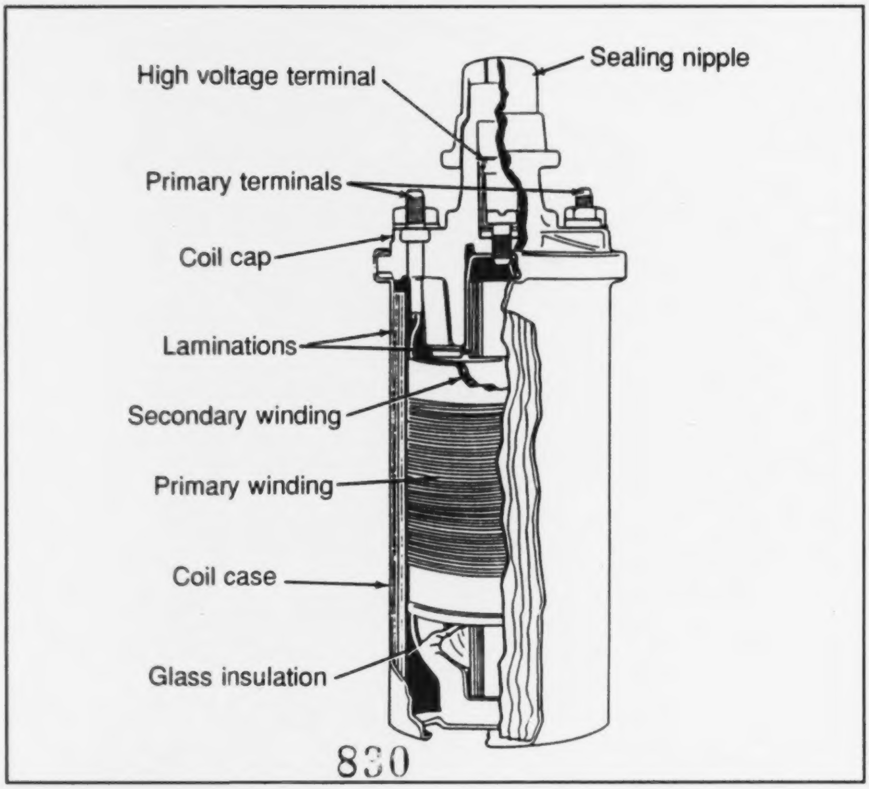
Required Activities/ Resources
- Transparency Master 5
- Ignition coil

Match the names of the parts of an ignition coil to an illustration.

Look at transparency 5 illustrating the parts of an ignition coil as your instructor explains its operation.

Examine the parts on an actual ignition coil.

FIGURE 5


Sealing nipple
High voltage terminal
Primary terminals
Coil cap
Laminations
Secondary winding
Primary winding
Coil case
Glass insulation

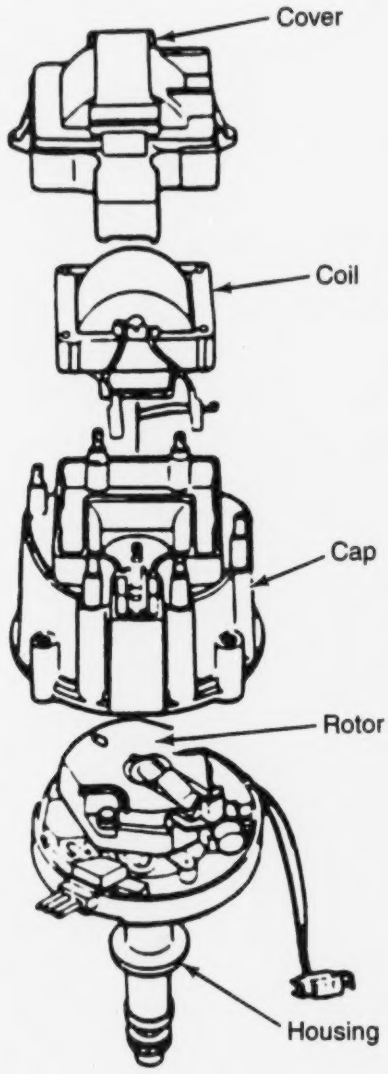
OBJECTIVE 14

Required Activities/
Resources
- Transparency Master 6

Match the names of the parts of a distributor to an illustration.

Look at transparency 6 illustrating the parts of a distributor as your instructor describes its operation.

FIGURE 6



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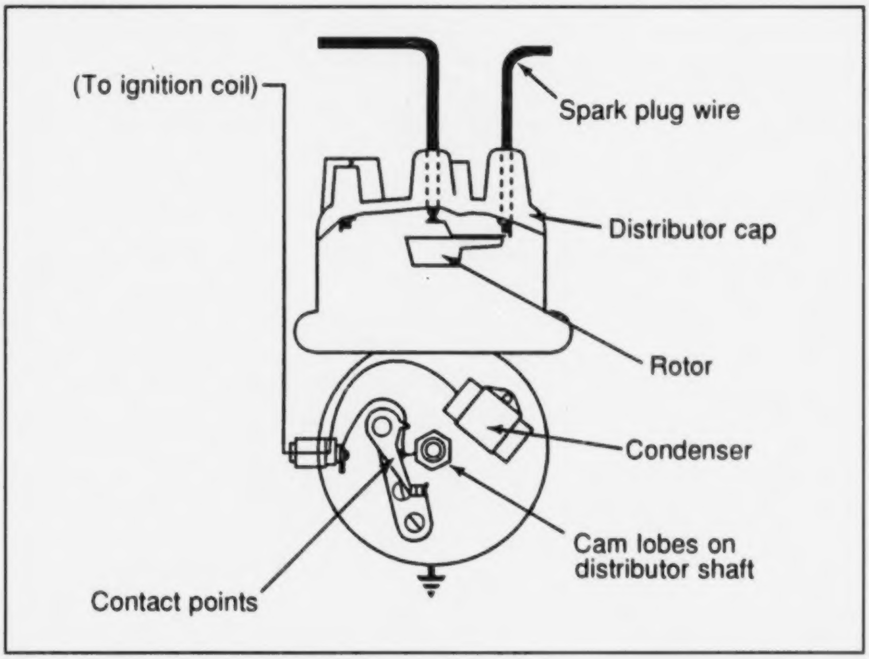
EXAMPLE: Distributor for a contact point ignitions system:

FIGURE 7


(To ignition coil)
Spark plug wire
Distributor cap
Rotor
Condenser
Cam lobes on distributor shaft
Contact points

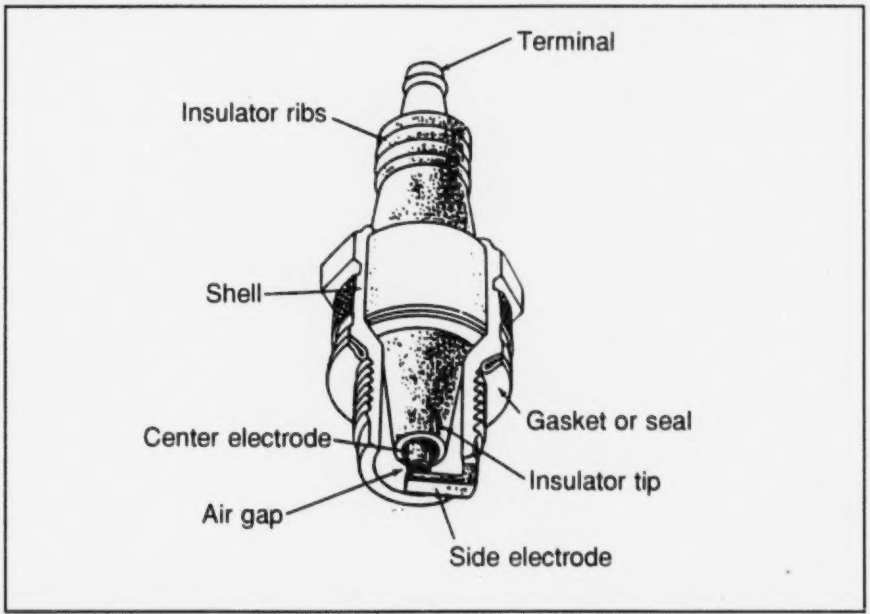
OBJECTIVE 15

Required Activities/ Resources
- Transparency Master 7

Label the parts of a spark plug indicated on an illustration.

Look at transparency 7 illustrating the parts of a spark plug as your instructor discusses its operation.

FIGURE 8


Terminal
Insulator ribs
Shell
Gasket or seal
Center electrode
Insulator tip
Air gap
Side electrode

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OBJECTIVE 16

Required Activities/
Resources
– Different types of spark plugs

Match the names of types of spark plugs to statements describing their qualities.

Examine different types of actual spark plugs in your classroom.

WORDS YOU SHOULD KNOW	
heat range	indicates how well a spark plug conducts heat away from the tip. A spark plug heat range is determined by the vehicle's manufacturer.
spark plug gap	the distance or *gap* the spark jumps from the center electrode to the side electrode. The wider the gap, the higher the voltage required to jump it.

- **hot spark plug** — has a long insulator tip and a hot operating temperature which allows it to burn off deposits, providing a self-cleaning action
- **cold spark plug** — has a short insulator tip and operates at a cooler temperature preventing overheating and preignition in engines that operate at high speeds
- **resistor spark plug** — will not cause noise or static on the vehicle's radio as spark plugs not of this type can

  NOTE: Resistor spark plugs are used on most new vehicles.

- **wide gap spark plug** — a multiple electrode spark plug requiring a wide jump from the center electrode to the side electrodes; this type burns hotter which helps reduce emissions

  NOTE: Wide gap spark plugs are used with modern electronic ignition systems because of the higher voltages and leaner air-fuel mixtures on these systems.

- **narrow gap spark plug** — a multiple electrode spark plug requiring a narrow jump and, therefore, less voltage from the center electrode to the side electrodes

  NOTE: Narrow gap spark plugs were the standard spark plugs on older engines with contact point ignition systems.

- **multiple electrode spark plug** — refers to a spark plug constructed with a single center electrode and 2-6 side electrodes

  ☑ **NOTE:** This type of electrode is said to burn hotter, reducing emissions.

- **single electrode spark plug** — refers to a spark plug constructed with a single center electrode and a single side electrode

OBJECTIVE 17

Required Activities/
Resources
– Explanation

Match the names of secondary pattern oscilloscope tests to the ignition system condition or function monitored by the test.

Listen as your instructor explains the importance of each test.

- **spark test** — determines if the high voltage surges from the ignition coil are being transferred to the spark plugs

  ☑ **NOTE:** This test is commonly used when an engine cranks but will not start.

- **secondary wire resistance test** — evaluates the condition of the coil wire and the spark plug wires

  ☑ **NOTE:** Resistance standards vary for different vehicles; check listing in the service manual.

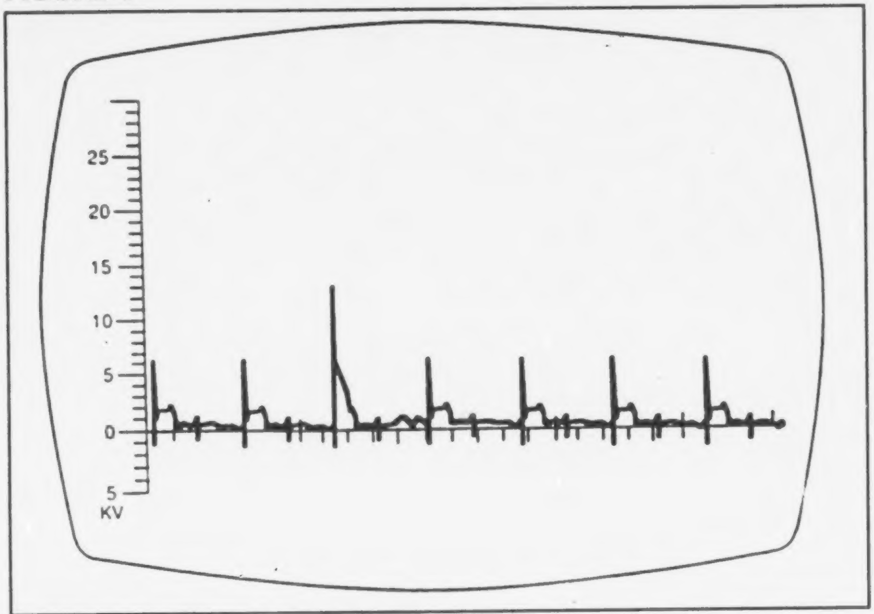
- **secondary wire insulation test** — determines whether voltage is being lost through poor insulation, a break in the wire, or other cause

OBJECTIVE 18

Identify abnormal oscilloscope patterns shown in illustrations.

- **High spark line**

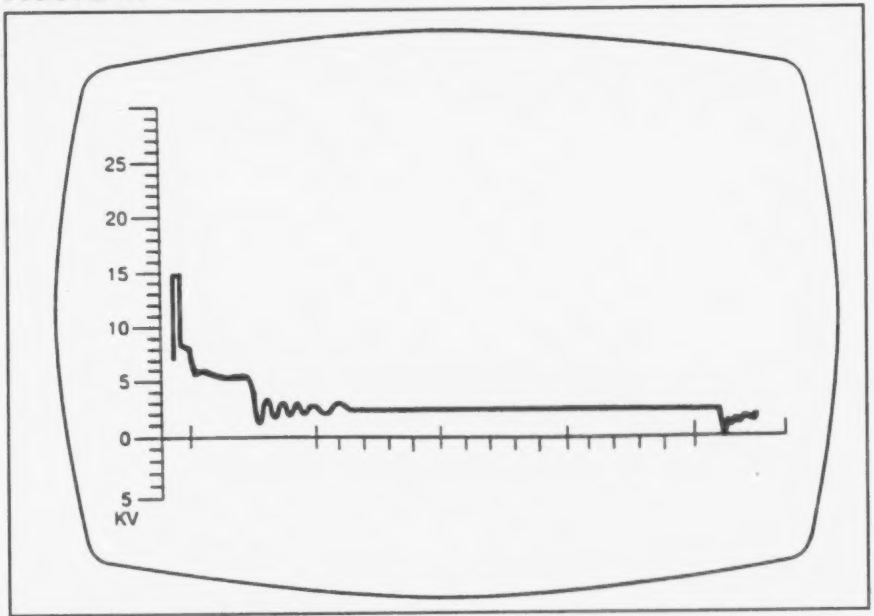
FIGURE 9



Used with permission of the Allen Group, Inc.

- **Low spark line**

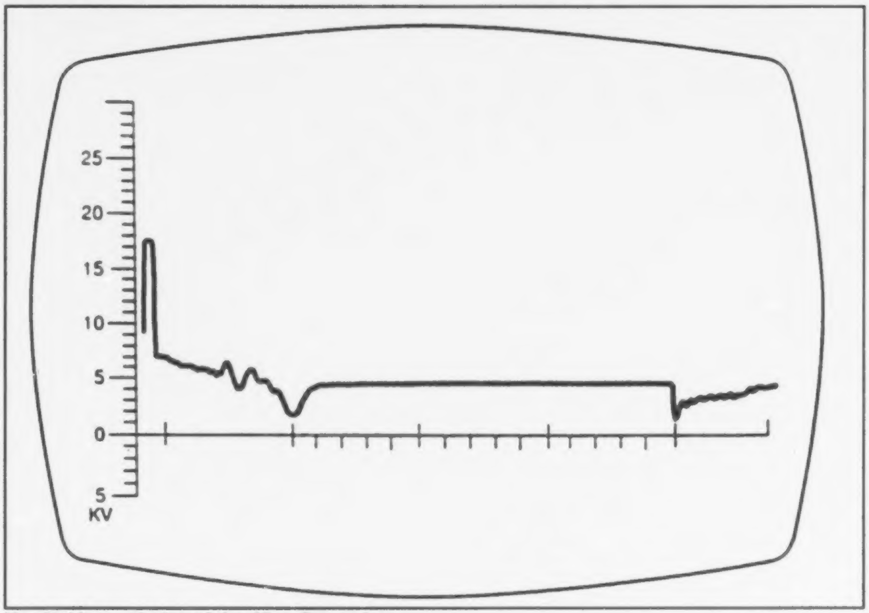
FIGURE 10



Used with permission of the Allen Group, Inc.

- **Oscillations lost**

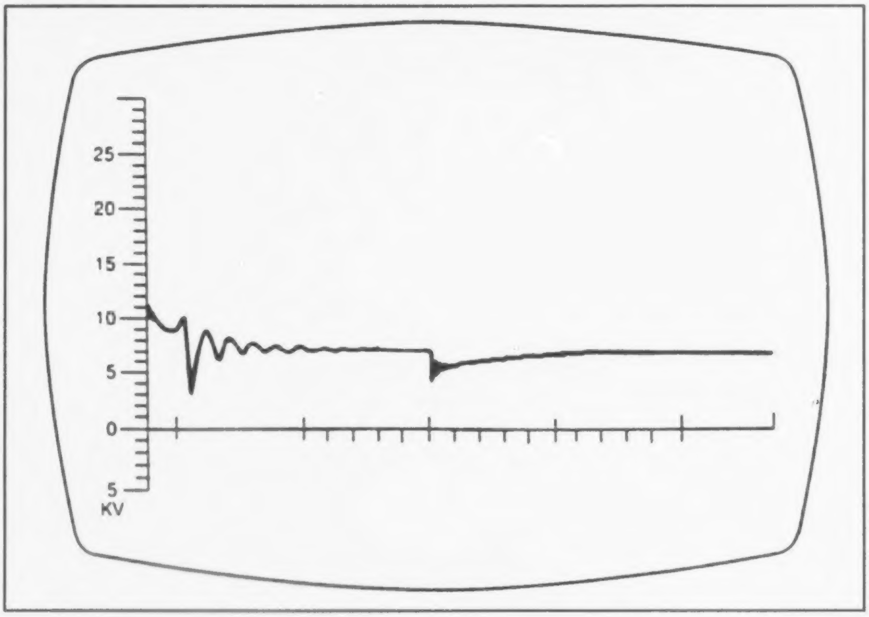
FIGURE 11



Used with permission of the Allen Group, Inc.

- **Firing line drops**

FIGURE 12



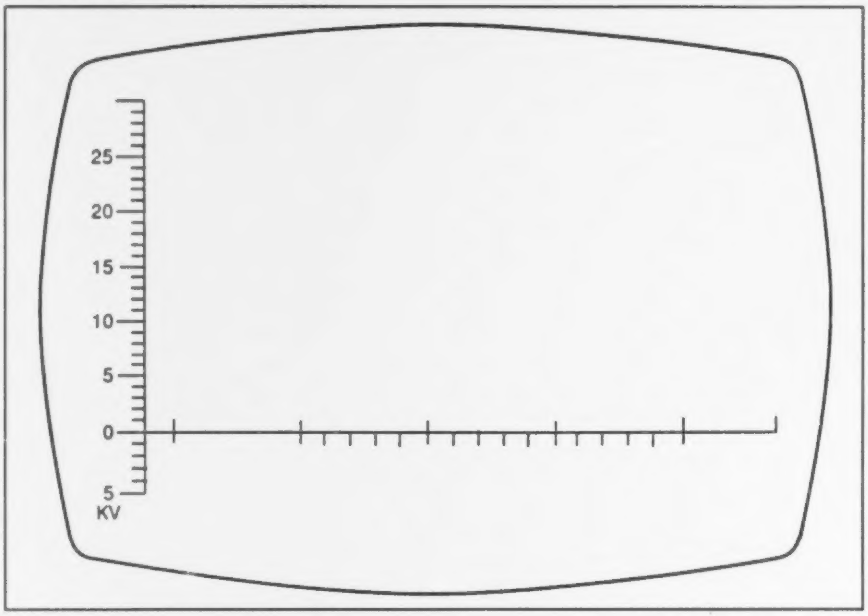
OBJECTIVE 19

Required Activities/
Resources
- Transparency Master 12 or Handout 1

Draw a typical primary oscilloscope pattern for an electronic distributor ignition.

Use transparency 12 or Handout 1 to guide you in drawing a typical primary oscilloscope pattern for an electronic distributor ignition on the blank oscilloscope screen below. Have your instructor check your work when you are finished.

FIGURE 13



NOTE: Electronic distributorless ignitions cannot be diagnosed by an oscilloscope unless the oscilloscope has been specially adapted. Distributorless ignition problems are normally diagnosed by computer.

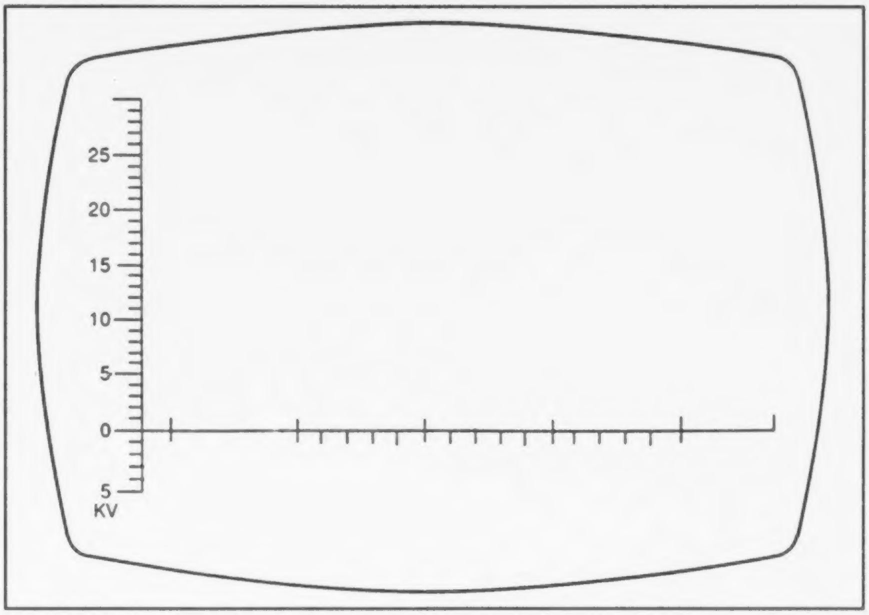
OBJECTIVE 20

Required Activities/
Resources
- Transparency Master 13 or Handout 1

Draw a typical primary oscilloscope pattern for a contact point ignition.

Use transparency 13 or Handout 1 to guide you in drawing a typical primary oscilloscope pattern for a contact point ignition on the blank oscilloscope screen below. Have your instructor check your work when you are finished.

FIGURE 14



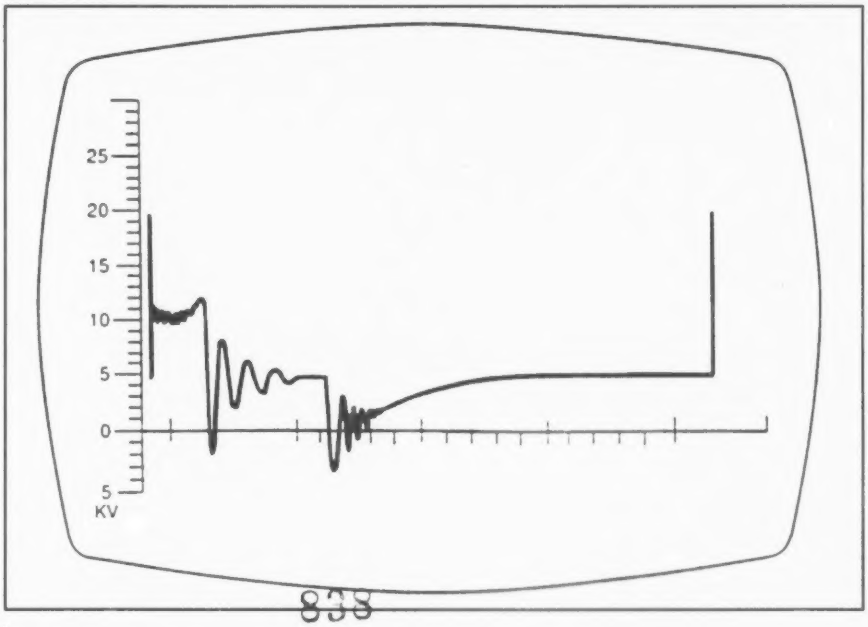
OBJECTIVE 21

Required Activities/ Resources
- Transparency Master 14

Circle the area of an oscilloscope pattern which corresponds to ignition coil ON.

Look at transparency 14 showing the area of a scope pattern which corresponds to ignition coil ON and circle that area on the pattern below. Have your instructor check your work when you are finished.

FIGURE 15



838

OBJECTIVE 22

Required Activities/
Resources
- Transparency Master 14
- Explanation

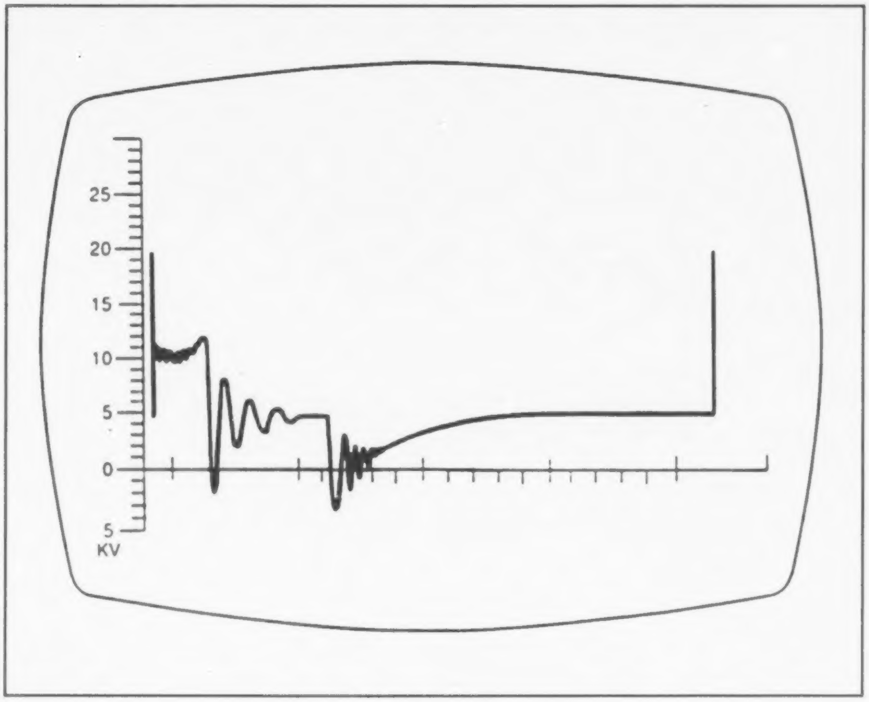
Circle the area of an oscilloscope pattern which corresponds to ignition coil OFF.

Look at transparency 14 showing the area of a scope pattern which corresponds to ignition coil OFF and circle that area on the pattern below. Have your instructor check your work when you are finished.

Listen as your instructor explains the term *dwell* and its use in ignition diagnosis.

WORDS YOU SHOULD KNOW	
dwell	the time between the point the ignition coil is turned on and the coil is turned off

FIGURE 16



OBJECTIVE 23

Complete Job Sheet 1.

OBJECTIVE 24

Complete Job Sheet 2.

OBJECTIVE 25 **Complete Job Sheet 3.**

OBJECTIVE 26 **Complete Job Sheet 4.**

OBJECTIVE 27 **Complete Job Sheet 5.**

OBJECTIVE 28 **Complete Job Sheet 6.**

OBJECTIVE 29 **State the purpose of a spark timing system.**

A spark timing control system adjusts the timing of the spark's ignition of the air-fuel mixture in the cylinder.

☑ **NOTE:** This coordinates the timing of the firing of the spark plug with the maximum compression of the air-fuel mixture in the cylinder — the exact moment that the most power can be obtained by igniting the mixture. Ignition timing is set based on the moment the number one cylinder reaches top dead center. Spark timing systems are sometimes called timing advance/retard systems.

OBJECTIVE 30 **Match the names of types of spark timing systems to descriptions of their operation.**

- **mechanical centrifugal** — Spring operated, it bases its timing action on engine rpms (revolutions per minute).
- **vacuum advance** — Vacuum operated, it bases its timing action on the amount of engine vacuum in the intake manifold.
- **electronic spark advance** — Computer operated, it bases its timing action on the readings it receives from the crank sensor and/or the cam sensor, as well as other sensors.

OBJECTIVE 31 **Match the names of types of ignition systems to the names of the spark timing systems used with them.**

- **Contact point ignition system**
    - ☐ Mechanical centrifugal
    - ☐ Vacuum advance

- **Electronic distributor ignition system**
  - ☐ Mechanical centrifugal
  - ☐ Vacuum advance
  - ☐ Electronic spark advance
- **Electronic distributorless ignition system**
  - ☐ Electronic spark advance

OBJECTIVE 32	**Complete Job Sheet 7.**
OBJECTIVE 33	**Complete Job Sheet 8.**
OBJECTIVE 34	**Complete Job Sheet 9.**
OBJECTIVE 35	**Complete Job Sheet 10.**
OBJECTIVE 36	**Complete Job Sheet 11.**
OBJECTIVE 37	**Complete the Assignment Sheet.**

ASSIGNMENT SHEET 7

SERVICING IGNITION SYSTEMS

Name ______________________________ Score __________

OBJECTIVE 37

Diagnose no-starting, engine misfire, poor driveability, spark knock, power loss, and poor mileage problems.

INTRODUCTION

Diagnosing ignition systems involves evaluating engine performance problems such as a no-start, engine misfire, poor driveability, spark knock or ping, power loss, and poor mileage.

When diagnosing any ignition system problem, the first step is always a visual inspection to evaluate the physical condition of the components. Next, an oscilloscope is hooked up to the system. The oscilloscope may be part of an engine computer analyzer or a stand alone unit. Although there will be several connections made for the hook-up between the oscilloscope and the ignition system, the number and location of these connections will depend on both the type of oscilloscope and the vehicle. Learning to use an oscilloscope and interpret the patterns it gives you is an important diagnostic skill that can only be learned with time and experience.

EQUIPMENT AND SUPPLIES

- Handout 2, Spark Plug Conditions
- Handout 3, No-Starting, Hard Starting, and Engine Misfire Diagnosis Chart
- Handout 4, Oscilloscope Patterns Diagnosis Chart

INSTRUCTIONS

Use Handouts 2, 3, and 4 to help you complete this Assignment Sheet. Read each of the following questions carefully, then select the answer for each that is most correct. Write the correct letter in the blank.

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

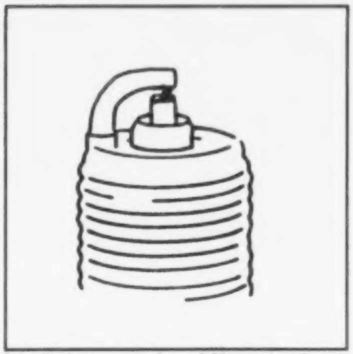
Functional Reading
- Interpret graphics and symbols
- Use content area vocabulary

General Science
- Investigate/apply technology

Cognitive Activities
- Draw conclusions
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure

____ 1. The spark plug shown at the right has a bridge of fuel deposits between the electrodes. What could cause this problem?

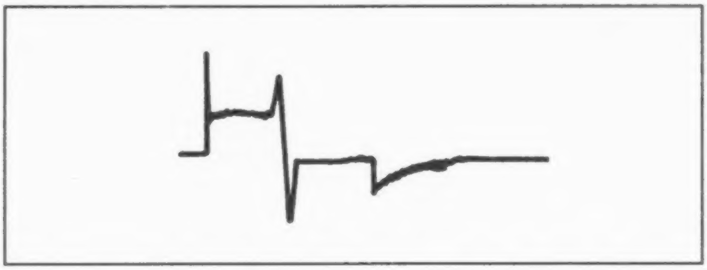

Used with permission of Champion Spark Plug Co.

A. Worn contact points
B. Excess additives in the fuel
C. Over advanced ignition timing
D. Clogged air cleaner

____ 2. You have found the cause of an engine miss to be a defective ignition coil. How could you correct the engine miss?

A. Replace the spark plug cables.
B. Clean the ignition coil.
C. Replace the ignition coil.
D. Clean the distributor cap.

____ 3. If you saw the following oscilloscope pattern, what corrective action would you make on the ignition system?



A. Replace the condenser.
B. Replace the spark plug.
C. Clean the spark plug.
D. Replace the coil or coil wire.

____ 4. The electronic distributorless vehicle in your shop backfires but fails to start. You determine that the spark plug cables are connected in the proper firing order. Technician A suggests that you next check the ignition timing. Technician B says that the problem is most likely to be in the distributor cap. Who is right?

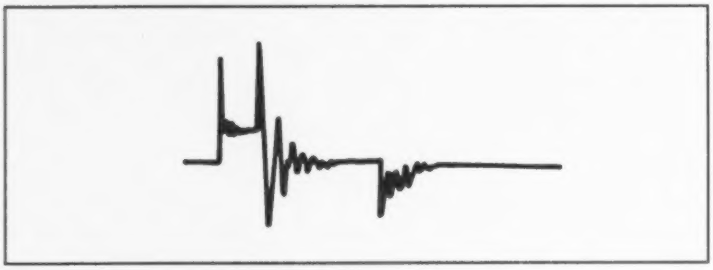
A. Technician A
B. Technician B

C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____ 5. The vehicle in the shop has been overheating, and you have checked for problems with the lubrication and cooling systems. What ignition system problem could be the cause?

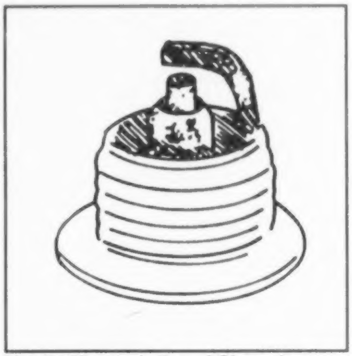
A. Fouled spark plugs
B. Faulty primary wiring
C. Spark plugs in too hot a heat range
D. Late ignition timing

_____ 6. What problem is indicated by the oscilloscope pattern below?



A. Weak coil or primary resistance
B. Floating valve (weak or broken valve spring)
C. Open plug wire or plug gap
D. Point bounce, weak spring

_____ 7. What could cause a spark plug to have splashed deposits like the one at right?



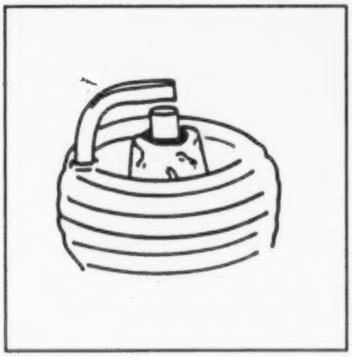
Used with permission of Champion Spark Plug Co.

A. Shock waves created by engine detonation
B. Delayed tune-up
C. Oil leaking into the combustion chamber
D. Improper spark plug heat range

_____ 8. If you find ash on a spark plug, what is the cause?

A. Wrong plug heat range
B. Weak ignition
C. Over-advanced ignition timing
D. Poor oil control

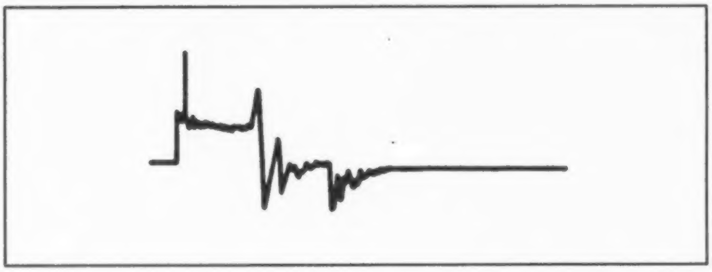
____ 9. What could cause spark plug damage like that seen at the right?



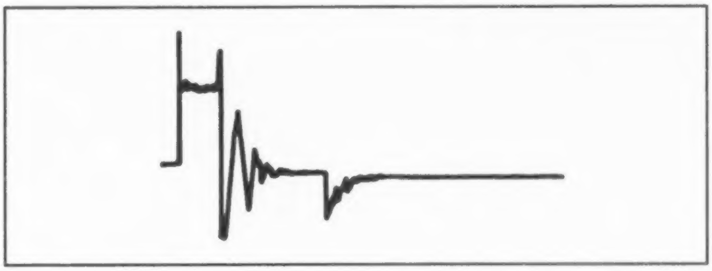
A. Poor oil control
B. Not enough coolant
C. Clogged air cleaner
D. Leaking exhaust manifold

____ 10. Which of the following oscilloscope patterns indicates a high resistance in the spark plug wire?

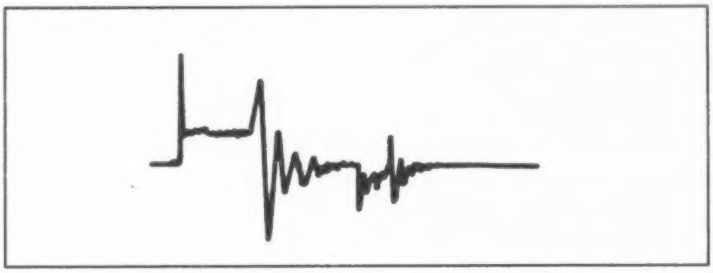
A.



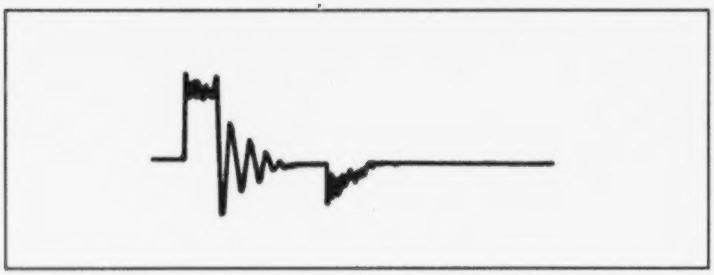
B.



C.



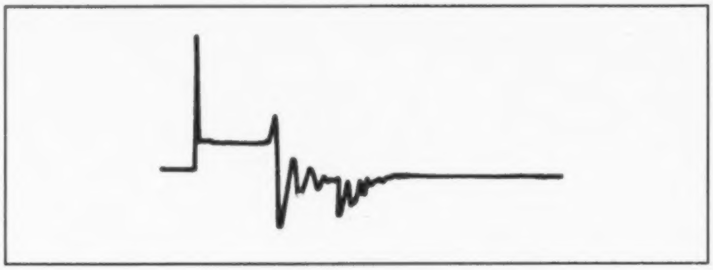
D.



____ 11. You have determined that advanced timing is causing engine run on. What action could you take to correct the problem?

A. Clean the spark plugs.
B. Replace the distributor cap.
C. Re-time the ignition.
D. Reconnect the spark plug cables.

____ 12. What ignition system problem may be the cause of the oscilloscope pattern below?



A. Floating valve (weak or broken spring)
B. Rich mixture
C. Retarded timing
D. Dirty distributor cap electrodes

____ 13. What could be the result of spark plug cables connected in incorrect firing order?

A. The engine overheats.
B. The engine has run on.
C. The engine backfires but fails to start.
D. The engine cranks but fails to start.

____ 14. What is the most common cause of engine misses?

A. Defective spark plug cables
B. High voltage leak

C. Defective coil
D. Improper timing

_____ 15. A spark plug has a yellow, varnish-like color. What is this condition called?

A. High-temperature glazing
B. Oil deposits
C. Preignition
D. Carbon deposits

JOB SHEET 1

SERVICING IGNITION SYSTEMS

7

Name ______________________________

OBJECTIVE 23

Inspect, test, repair, and replace the ignition primary circuit wiring and components.

INTRODUCTION

As an Engine Performance Technician, you will find the only situation in which you will need to check an engine's primary wiring is when the engine cranks normally but will not start. Information on battery testing is in Unit 2, Servicing Starting and Charging Systems.

Problems in the primary circuit usually involve either low source voltage from the battery or charging system or high resistance in the primary circuit. Both types of problems are diagnosed using a voltmeter. Low source voltage problems can be caused by a discharged battery, low charging voltage, or high current draw at the starter motor. High primary resistance problems may result from a lack of voltage to the ignition system, defective contact points and condenser, a faulty ignition coil or module, or loose, damaged, or corroded primary wiring and connectors. Refer to an appropriate service manual for normal scope readings, trouble diagnosis, and replacement procedures.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 2

SERVICING IGNITION SYSTEMS

7

Name ____

OBJECTIVE 24

Inspect, test, adjust, service, repair, and replace the ignition points and condenser.

INTRODUCTION

For older vehicles, it is recommended that the contact points and condenser be adjusted every 6,000 miles and replaced every 12,000 miles. Defective contact points could cause an engine to experience a no-start, high speed missing, or other ignition related problem. A defective condenser could cause point arcing and burning, with the primary current flowing to the ground, causing a no-start situation. Consequently, the contact points and the condenser should be tested when any of these problems occur, and the engine is running poorly or not at all.

The location of the contact points varies with the vehicle. They are usually internal with external, clipped on, or screwed on multiple condensers. Since the location and installation of the contact points and condenser varies with the age and model of the vehicle, always consult the vehicle service manual.

EQUIPMENT AND SUPPLIES

- Vehicle with a contact point type ignition system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.

3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.

2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.

1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 3

SERVICING IGNITION SYSTEMS

Name ______________________________

OBJECTIVE 25

Inspect, test, service, repair, and replace the ignition system secondary circuit wiring and components.

Required Activities/
Resources
- Handout 2
- Defective spark plugs

Use Handout 2 and examples of defective spark plugs to help you learn to diagnose spark plug conditions and their causes.

INTRODUCTION

As an Engine Performance Technician, you will need to be aware of possible problems that may affect the secondary circuit wiring and components. Ignition coil testing and servicing will be covered in Job Sheet 4, and distributor testing and servicing will be covered in Job Sheet 11.

Engine power loss, misfire, a hard start, or a no-start can all be conditions caused by worn or damaged secondary circuit wiring and components. These conditions could mean that the wiring has a broken or burned conductor or deteriorated insulation. A broken conductor prevents current from reaching the spark plug. Defective insulation may cause voltage to leak through the insulation to ground or to another wire, preventing the spark plug from firing properly.

The following guidelines should allow a better visual inspection and prevent further damage when servicing secondary circuit wiring and components.

Guidelines:

- Disconnect a cable by grasping the boot and twisting and pulling at the same time. Do not pull on the cable.
- Remove the gaskets on gasket-type plugs in metal cylinders before installing the plugs.
- Install cables and spark plugs with gaskets according to the manufacturer's recommendations.
- Visually inspect the tapered seats of cylinder heads and plugs to make certain they are clean and free from nicks.

- Install the plugs into the engine by hand. Use nylon or rubber tubing on the plug terminals or insulators to turn hard-to-reach plugs.
- Be sure the plugs turn freely in their holes and are not cross threaded. If the plugs do not turn easily, clean the cylinder head threads with a thread chaser.
- Do not overtighten spark plugs, particularly in an aluminum cylinder head.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1

• Practice good work habits/attitudes	Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 4

SERVICING IGNITION SYSTEMS

Name ____

OBJECTIVE 26 **Inspect, test, and replace ignition coils.**

INTRODUCTION

Don't overlook the ignition coils when diagnosing and servicing ignition systems. A defective coil can cause engine stalling, missing, loss of power, or no-start conditions.

The vast difference between makes and models of vehicles requires reference to an appropriate service manual for specific instructions when performing tests for coil resistance, current draw, and polarity as well as replacement of ignition coils on the vehicle you are servicing.

Guidelines:

- Clean the coil with a clean cloth and an approved cleaning solvent and wipe it dry.
- Inspect the coil tower for cracks, carbon tracking, and arcing and burning of the tower. Replace the coil if it is defective.
- Inspect the secondary cable and boot for damage or carbon tracking. Replace them if they are damaged.
- Replace the cable and boot if the coil is damaged. A damaged cable or boot on a new coil will cause coil failure.
- When performing a coil resistance test, test the primary winding at the lowest scale on the ohmmeter. A reading above or below manufacturer's specifications indicates the coil needs replacing. Test the secondary winding at the highest scale on the ohmmeter. A reading above or below the manufacturer's specifications indicates the coil needs replacing.
- Shorted coil windings tested at the lowest scale on the ohmmeter should indicate infinite resistance. A reading lower than infinity means that the windings are shorted to the coil case and the coil must be replaced.
- When testing ignition coil current draw, high ammeter readings indicate a short circuit or an incorrectly installed coil or ignition (ballast) resistor. Low ammeter readings indicate a discharged battery, loose or corroded primary connections, or high resistance in the primary circuit.

- Reversed coil polarity reduces maximum secondary voltage and causes engine misfire or a spark plug not to fire under heavy load or high speed. Coil polarity can be checked with either an oscilloscope or a voltmeter. If you test with a voltmeter, make sure it is a negative reading voltmeter on which the dial is graduated on the negative side of zero as well as the positive side. Without the negative reading, the voltmeter can be damaged during the test.

EQUIPMENT AND SUPPLIES

- Vehicle with an ignition coil (not a distributorless ignition)
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1

Product appearance meets industry standards	4	3	2	1

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 5	*SERVICING IGNITION SYSTEMS*

Name ______________________________

OBJECTIVE 27

Inspect, test, and replace an electronic ignition wiring harness and connectors.

INTRODUCTION

Ignition systems carry high voltage current. This current flows through a series of insulated wires wrapped together with electrical tape to form a harness. It is important that ignition system wires be kept away from other high voltage sources. Unexpected alien voltage will disrupt the normal voltage, carrying unwanted signals to the control unit and disrupting operation. To protect the wiring harness from other high voltage sources, it should be kept away from alternators, spark plugs and any high voltage wires. Connectors are attached to the wires so they can be easily removed and installed.

Due to the variations in makes and models, always consult an appropriate service manual for the proper inspection, testing, and replacement instructions.

EQUIPMENT AND SUPPLIES

- Vehicle with an electronic ignition system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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858

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 6

SERVICING IGNITION SYSTEMS

Name ______________________________

OBJECTIVE 28

Inspect, test, and replace electronic ignition system pick-up sensors or triggering devices.

INTRODUCTION

When the engine computer detects a problem with a sensor, it immediately compensates for the defective sensor. The computer may be able to compensate for the problem for a short time, and engine performance may be affected very little, if at all. However, the failed sensor will eventually result in increased emissions or engine performance problems such as engine miss, a hard start, or loss of engine power. When engine performance problems arise, the control panel will show a "check engine" light. Because of the complexity of engine operation and the differences between vehicles, always consult an appropriate vehicle service manual.

EQUIPMENT AND SUPPLIES

- Vehicle with an electronic ignition system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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800

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 7

SERVICING IGNITION SYSTEMS

7

Name ______________________________

OBJECTIVE 32

Test and adjust spark timing systems.

The relationship between piston position and the opening of the primary circuit is referred to as the basic ignition timing. The spark timing system advances or retards the timing from the basic timing setting as engine speed and load change. An over-advanced timing can cause spark knock or pinging, engine overheating, engine run-on, or hard starting. Retarded timing can cause poor fuel economy, lack of engine power, or hard starting.

Timing is tested by one of three different methods: (1) by a computer, (2) by a timing light, or (3) by a magnetic timing unit. Which method you use will depend on the vehicle and the type of spark timing system it has. The following guidelines may be helpful.

Guidelines:

- Have the engine at a normal operating temperature. If the engine is cold or overheated, you may get an inaccurate reading.
- Set timing at the normal idling speed unless otherwise indicated by the service manual.
- Run the engine on basic timing. To do this, you may be required to disconnect a hose or unplug an electrical connection. If so, consult the service manual for the procedure.
- Adjust the timing in relation to top dead center (TDC) on the compression stroke at the number 1 cylinder.

On contact point ignition systems, the distributor operates as a mechanical switch turning the primary circuit on and off. It mechanically adjusts the timing of the spark through either a mechanical centrifugal or a vacuum advance spark timing control system. Unlike electronic ignition systems, which normally do not require a timing adjustment once they are set, contact point ignition systems usually require the timing to be set periodically. This is necessary because wear on the contact points and rubbing blocks cause the ignition timing and dwell to change. Incorrect timing can cause various engine performance problems.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 8

SERVICING IGNITION SYSTEMS

7

Name ______________________________

OBJECTIVE 33 **Inspect, test, repair, and replace the components of a spark timing system.**

INTRODUCTION

An engine that misses or pings can be an indication that the spark timing system needs to be repaired or replaced. When the spark timing system is operating erratically due to a defective part, it can cause the engine to miss. A defective advance mechanism allowing excessively advanced timing can be a cause of engine pinging.

The following causes of over-advanced or retarded timing for mechanical centrifugal or vacuum advance spark systems should prove helpful as you check and adjust the spark timing system.

Over-advanced timing can be caused by the following:

- Broken or weak springs in the centrifugal advance mechanism
- Centrifugal advance weights stuck in the "out" position
- Incorrect vacuum advance connection to the distributor
- Defective vacuum delay valve, coolant vacuum switch, or solenoid
- Worn timing chain or belt

Retarded timing can be caused by the following:

- Incorrect basic timing
- Centrifugal advance weights sticking
- Leaking vacuum diaphragm or hose
- Binding breaker plate in distributor
- Wrong vacuum hose connection
- Defective or plugged vacuum delay valve, coolant vacuum switch, or solenoid
- Worn timing chain or belt

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB
SHEET 9

SERVICING IGNITION SYSTEMS

Name ______________________________

OBJECTIVE 34

Inspect, test, repair, and replace electrical/electronic components and circuits of a spark timing system.

INTRODUCTION

Vehicles with electronic ignitions usually have electronic spark advance timing systems. In electronic spark advance timing systems, the ignition control module mounts on the distributor housing and operates with the engine computer to control spark timing.

Electronic components and circuits of an electronic spark advance spark timing system vary with individual manufacturers. Consult an appropriate service manual for information applying to the vehicle you are servicing.

Guidelines:

- Always consult the wiring diagram in the appropriate service manual.
- Because of extremely high voltage, be very cautious as you test electrical/electronic components.

  ☑ **NOTE:** Do not ground the coils during testing.

- Wiggle the wires to check for a loose connection.
- Check one wire at a time when inspecting spark plug wires.
- If you replace the ignition control module, apply a thick coat of silicone dielectric grease under the replacement to ensure cooling.

  ☑ **NOTE:** Silicone dielectric grease is a special heat conductive grease.

EQUIPMENT AND SUPPLIES

- Vehicle with an electronic spark advance spark timing system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 10

SERVICING IGNITION SYSTEMS

Name ______________________________

OBJECTIVE 35 **Inspect, test, and service a distributor.**

INTRODUCTION

A distributor contains a switch that opens and closes the primary circuit at the proper time, distributing the resulting high voltage surges to the spark plugs. Although distributors vary with different types of engines, general parts and functions are similar with the only basic difference between types being the use of an electronic switch instead of contact points to control voltage flow in an electronic distributor ignition system.

A malfunctioning distributor can cause various engine problems. Contact point distributors should be checked for shaft, bushing, and cam wear, dwell angle and variation, and contact point alignment.

Today many distributors can be tested without removing them from the vehicle, and servicing them does not necessarily mean taking them completely apart. Although you must follow an appropriate service manual to service a distributor, the following guidelines should be helpful.

Manual inspection of the distributor should include checking:

- The shaft for obvious worn ends, sides, or inadequate lubrication
- The cam lobes for wear or inadequate lubrication
- The advance weights for inadequate lubrication
- The breaker plate or pickup coil for looseness or worn bearings
- The primary wiring for worn insulation or broken connectors

If the distributor is still installed in a vehicle, check it for:

- Correct point installation and alignment

- Dirt or grease on the mounting screws, leads, connectors, or the point assembly

  ☑ **NOTE:** Dirt can cause resistance in the primary circuit.

- Misalignment of the rubbing block of the cam

  ☑ **NOTE:** Misalignment can cause erratic ignition operation and shorten point life.

- A bad primary wire, poor primary wire connection, dirty or oxidized points, a dirty breaker plate, or poor connection of the grounded plate point or wire, all of which can cause high resistance problems

- Weak, uneven spring tension or a binding pivot

  ☑ **NOTE:** This condition is called *point float* because the points do not close properly at high speeds.

- Weak spring tension, a binding point, or pitted or misaligned points

  ☑ **NOTE:** This condition is called *point bounce* because the points close and then bounce open briefly at the start of the dwell period.

EQUIPMENT AND SUPPLIES

- Vehicle with a distributor
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 11

SERVICING IGNITION SYSTEMS

7

Name ______________________________

OBJECTIVE 36

Inspect, test, and replace an electronic ignition system control unit.

INTRODUCTION

Unlike contact point ignition systems, both electronic and distributorless ignition systems have control unit modules which turn the ignition coil primary current on and off. Extreme heat can cause these modules to fail. Any no-start situation calls for an inspection of the control unit module.

These modules are installed in various places in different vehicles. They may be located on the side of the distributor, in the engine compartment, inside the distributor, or under the dash. Consult the vehicle service manual for the location of the ignition control module on the vehicle you are servicing.

☑ **NOTE:** As with all tasks involving electronics, be careful performing the procedures. Make sure the unit is properly grounded, tested, and actually does need replacing.

EQUIPMENT AND SUPPLIES

- Vehicle with an electronic ignition system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

OBJECTIVE SHEET

SERVICING FUEL DELIVERY SYSTEMS

8

INTRODUCTION

The fuel delivery system in an internal combustion engine is designed to store a sufficient amount of fuel to run the engine, to transport the fuel from the storage tank to the engine, and to deliver the fuel in a form which allows the engine to operate at its maximum efficiency. In early model vehicles the fuel delivery system consisted of a tank, a simple fuel pump, and a carburetor. Today the situation is much different. Fuel injection, fuel systems designed for improved fuels, and the demand for cleaner burning engines have created a need for emission control devices, engine sensors, and engine computers. An Engine Performance Technician needs a great deal of specialized knowledge to service modern fuel delivery systems.

PREREQUISITE

Unit 7, "Servicing Ignition Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS

PREREADING:	Read Stuart F. Brown's article, "The Theme Is Green - Hydrogen Engines," in *Popular Science* magazine, February 1992, pp. 50-55. As you read, consider what technological advances have been made in producing engines that use hydrogen fuel systems and how those advances could reduce air pollution.
WRITING:	Write a short (one paragraph to one page) explanation of some of the advantages and disadvantages of hydrogen as a future fuel for vehicles.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment Sheet and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. List the two main classifications of fuel delivery systems.
2. Compare and contrast the two main classifications of fuel delivery systems.
3. Name three types of fuel delivery systems shown in illustrations.
4. Describe the operation of the three types of fuel delivery systems.
5. Label fuel delivery system parts indicated on illustrations.
6. Match the names of fuel delivery system parts to descriptions of their functions.
7. Inspect, clean, and replace fuel delivery system components. (Job Sheet 1)
8. Name three types of fuel pumps shown in illustrations.
9. State the amount of fuel pressure present during the operation of different types of fuel systems.
10. Name types of fuel filters from examples shown in your classroom.
11. Compare and contrast fuel filters used in carbureted type fuel delivery systems and fuel filters used in injector type fuel delivery systems.
12. Match the names of types of fuel system diagnostic tests to statements describing the tests' purposes.
13. Inspect, test, and replace fuel pumps, pump control systems, and fuel filters. (Job Sheet 2)
14. Inspect, service, repair, and replace air filtration system components. (Job Sheet 3)
15. List common fuel contaminants.
16. Remove and replace the fuel tank and fuel gauge sending unit. (Job Sheet 4)
17. Inspect and replace fuel system components and check fuel condition. (Job Sheet 5)
18. Test an oxygen sensor. (Job Sheet 6)

19. Remove and replace an oxygen sensor. (Job Sheet 7)

20. Diagnose fuel delivery system problems. (Assignment Sheet)

SERVICING FUEL DELIVERY SYSTEMS

OBJECTIVE 1

List the two main classifications of fuel delivery systems.

- carbureted
- fuel injected

OBJECTIVE 2

Compare and contrast the two main classifications of fuel delivery systems.

WORDS YOU SHOULD KNOW	
fuel	any combustible substance
air-fuel mixture	the vaporized blend of air and gasoline used as fuel in a gasoline-powered internal combustion engine

	Carbureted	Fuel Injected
Delivers fuel to the engine	X	X
Older technology	X	
Newer technology		X
More precise metering of fuel		X
More efficient and cost effective		X
Uses pressure to mix air and fuel		X
Uses vacuum to mix air and fuel	X	
Responds quickly to changing conditions (air temperature, vehicle speed, engine temperature, etc.)		X
Produces fewer exhaust emissions		X

OBJECTIVE 3

Required Activities/ Resources
- Vehicles with the three types of fuel delivery systems

Name three types of fuel delivery systems shown in illustrations.

Look at the three types of fuel delivery systems as your instructor shows them to you on actual vehicles.

☑ **NOTE:** Refer to the names and illustrations in objective 5.

OBJECTIVE 4

Required Activities/ Resources
- Transparency Masters 1, 2, and 3

Describe the operation of the three types of fuel delivery systems.

Look at transparencies 1, 2, and 3 as your instructor describes the operation of the three types of fuel delivery systems.

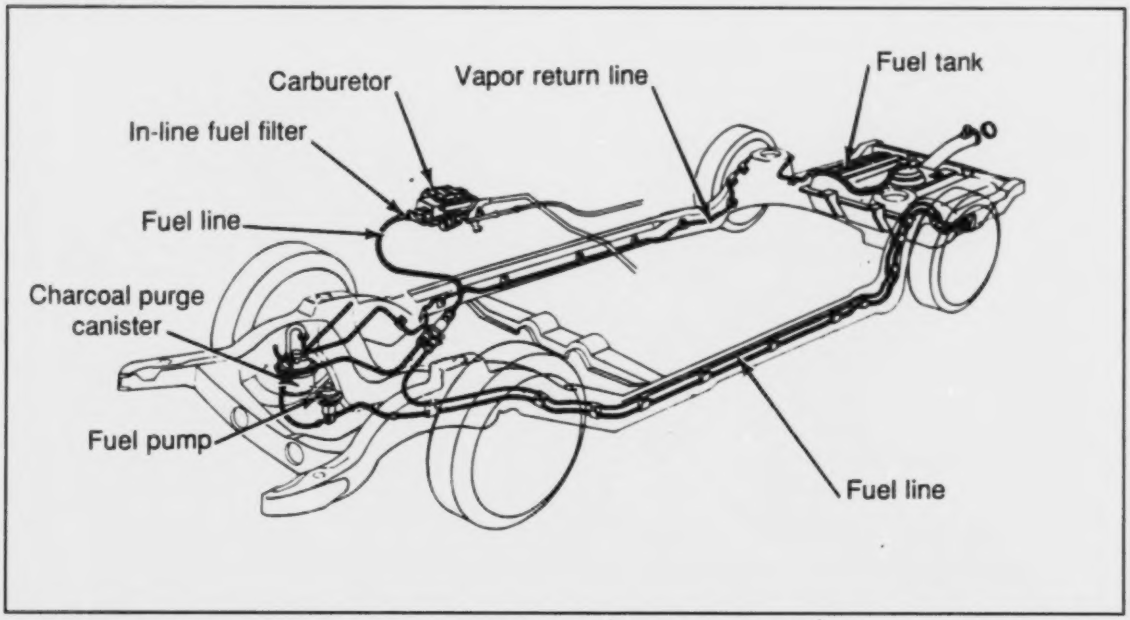
☑ **NOTE:** Refer to the descriptions of operation under the illustrations in objective 5.

OBJECTIVE 5

Label fuel delivery system parts indicated on illustrations.

- **carbureted fuel delivery system**

FIGURE 1



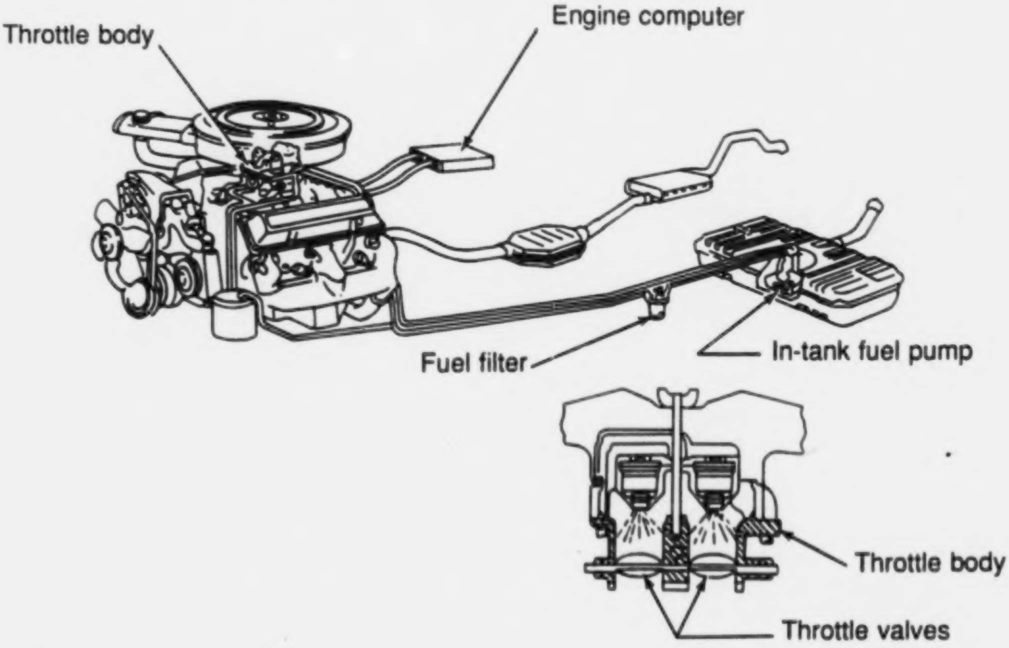
Reprinted with permission of the Glencoe Division of the Macmillan/McGraw-Hill School Publishing Co., from *Automotive Fuel, Lubricating, and Cooling Systems*, 6th ed., by William H. Crouse and Donald L. Anglin, © 1981.

Description of operation: Air and fuel is mixed in the carburetor and the intake manifold delivers the mixture to the intake valve of each cylinder.

☑ **NOTE:** Vehicles with carbureted fuel delivery systems are no longer being produced; however, many remain in operation.

- **throttle body fuel injection system**

FIGURE 2

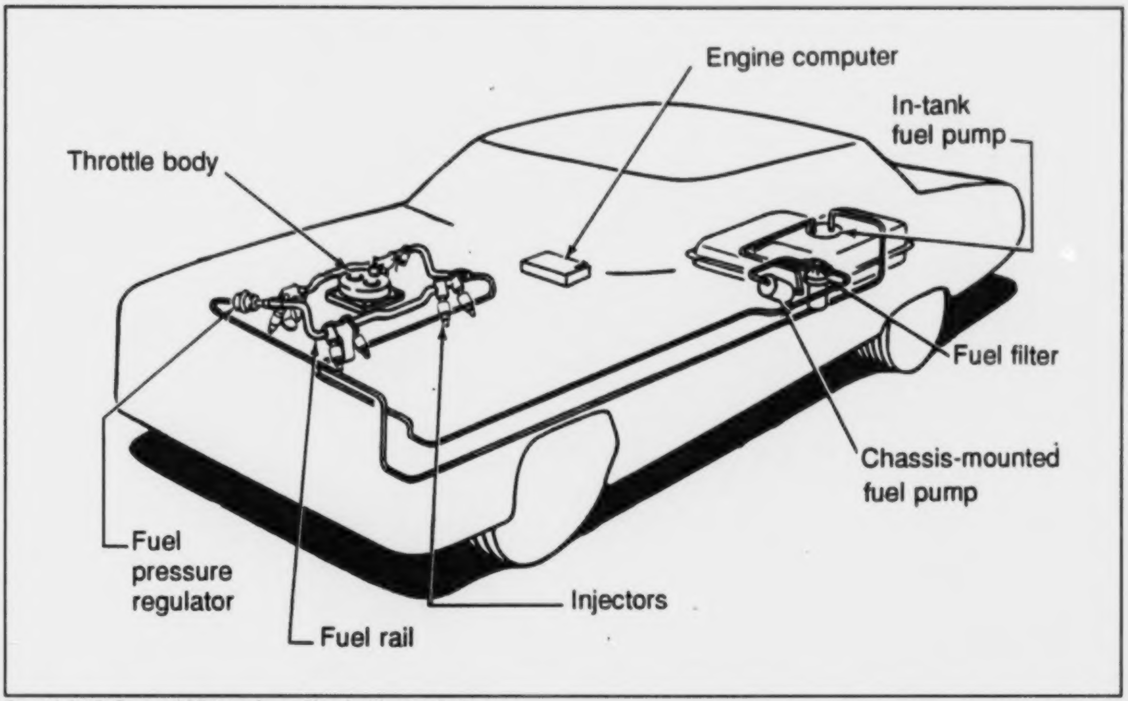

Throttle body
Engine computer
Fuel filter
In-tank fuel pump
Throttle body
Throttle valves

Reprinted with permission of the Glencoe Division of the Macmillan/McGraw-Hill School Publishing Co., from *Auto Study Guide*, by William H. Crouse and Donald L. Anglin, © 1984.

Description of operation: One or two injectors mix fuel into the air in the intake manifold which then delivers the mixture to each cylinder.

- **port fuel injection system**

FIGURE 3


Engine computer
In-tank fuel pump
Throttle body
Fuel filter
Chassis-mounted fuel pump
Fuel pressure regulator
Injectors
Fuel rail

Copyright © General Motors Corp. Used with permission.

Description of operation: An injector for each cylinder injects the fuel into the intake port where it is mixed with air

☑ **NOTE:** In fuel injection systems, the amount of fuel going to each injector is controlled by the engine computer which uses information from a number of sensors to tell it how much fuel is needed. The sensors monitor such things as air-fuel mixture, engine rpm, engine coolant temperature, engine load, air pressure, detonation noise, intake air temperature, vehicle road speed, throttle position, transmission gear position, and air conditioner operation. Computerized carbureted systems also use sensors.

OBJECTIVE 6

Optional Activities/
Resources in
Instructor's Guide

Match the names of fuel delivery system parts to descriptions of their functions.

- **carburetor** — meters and mixes gasoline with air before it enters the intake manifold
- **charcoal canister** — stores fuel vapors from the fuel tank and the carburetor float bowl and/or intake manifold
- **engine computer** — monitors vehicle operation and regulates the fuel injectors for maximum efficiency
- **fuel filter** — removes contaminants from the fuel before they reach the engine
- **fuel line** — carries the fuel from the fuel tank to the engine
- **fuel pressure regulator** — maintains steady fuel pressure in the fuel system
- **fuel pump** — propels the fuel from the fuel tank to the engine and provides the pressure necessary for proper system operation
- **fuel rail** — directs pressure-regulated fuel to the injectors in a port fuel injection system
- **fuel tank** — holds the fuel supply for the vehicle
- **injector** — sprays vaporized fuel into the intake manifold or intake port
- **throttle body** — contains the vaporized fuel before it is regulated into the manifold to be mixed with air
- **throttle valve** — regulates the flow of air or air-fuel mixture
- **vapor return line** — returns gasoline vapors to the fuel tank to prevent them from venting into the atmosphere

OBJECTIVE 7

Complete Job Sheet 1.

OBJECTIVE 8

Required Activities/ Resources
- Transparency Masters 4, 5, and 6
- Three types of fuel pumps

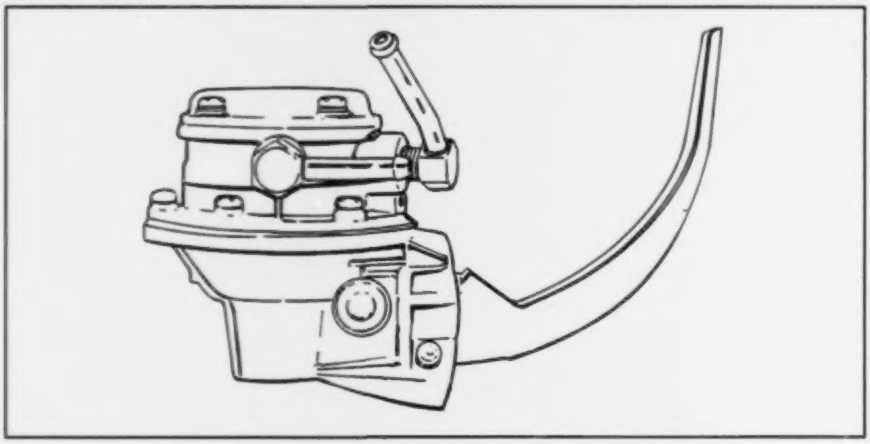
Name three types of fuel pumps shown in illustrations.

Look at transparencies 4, 5, and 6 as your instructor describes the differences between the three types of fuel pumps.

Examine actual examples of the three types of pumps.

- **mechanical fuel pump**

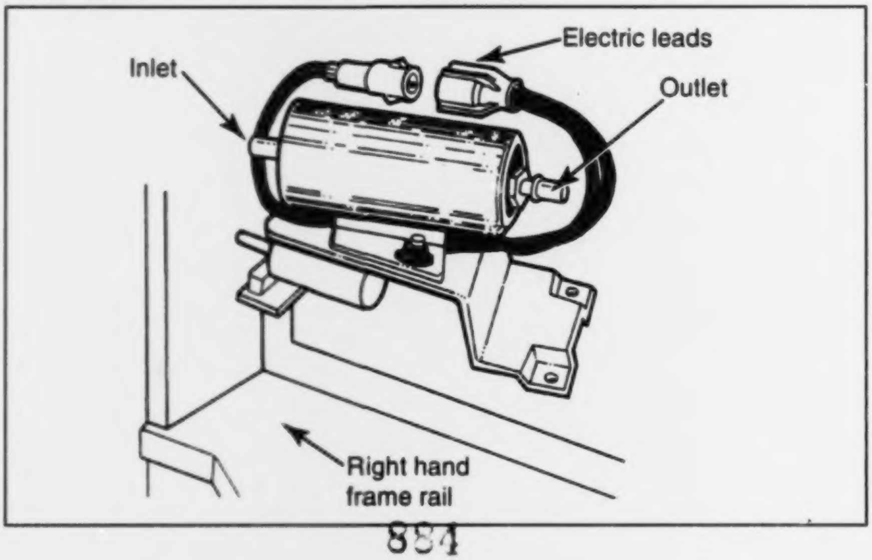
FIGURE 4



NOTE: Mechanical fuel pumps are powered by the camshaft.

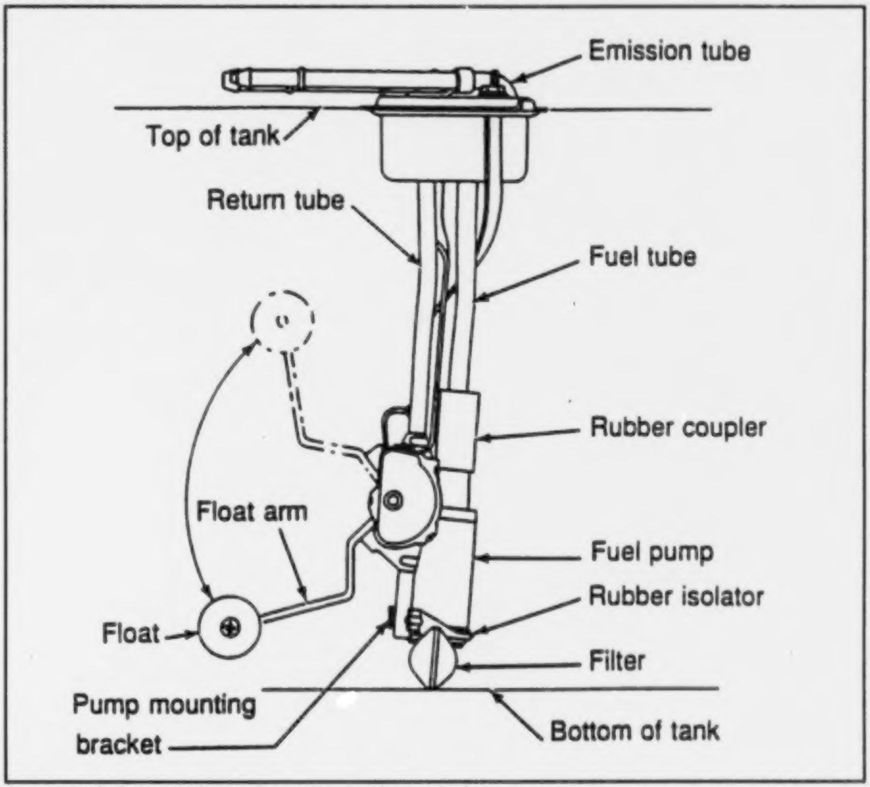
- **external electric fuel pump**

FIGURE 5



- **tank-mounted electric fuel pump**

FIGURE 6


Emission tube
Top of tank
Return tube
Fuel tube
Rubber coupler
Float arm
Fuel pump
Rubber isolator
Float
Filter
Pump mounting bracket
Bottom of tank

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OBJECTIVE 9

Required Activities/
Resources
– Explanation

State the amount of fuel pressure present during the operation of different types of fuel systems.

Listen as your instructor explains what alterations are made in fuel system components to enable them to handle the higher pressures used by fuel injected engines.

Type of Fuel System	Fuel Pressure
Carbureted	5 psi (pounds per square inch)
Throttle body fuel injection	9 - 15 psi
Port fuel injection	30 - 40 psi

NOTE: These pressures are approximate. Because of different pressure requirements, fuel lines, pumps, and other fuel delivery system parts are not interchangeable. Always consult the proper service manual to determine the exact pressure and the correct parts to be used for the vehicle you are servicing .

OBJECTIVE 10

Required Activities/
Resources
– Fuel filters

Name types of fuel filters from examples shown in your classroom.

☞ Examine the display of fuel filters your instructor has set up in your classroom.

- **carburetor-mounted canister-type filter**

  ☑ **NOTE:** This type of filter may be found in many older model vehicles. In order to inspect or replace the filter element, it is necessary to detach the fuel line from the end of the filter housing and then unscrew the housing from the carburetor.

- **carburetor-mounted paper filter**

  ☑ **NOTE:** This type of filter is a newer version of the carburetor-mounted canister-type filter. The filter is made of disposable pleated paper and can be replaced by unscrewing the fitting on the carburetor housing.

- **fuel pump-mounted filter**

  ☑ **NOTE:** This type of filter is more likely to be found on engines with fuel injection. When the fuel filter is a part of the fuel pump, it is usually possible to replace the filter simply by unscrewing the element holder and replacing it.

- **in-line canister-type filter**

  ☑ **NOTE:** The *in-line canister-type* fuel filter can be used in either carbureted or fuel injection engines. It may be located anywhere along the fuel line. In-line filters have a larger capacity and are usually the most cost-effective way of filtering. They are also often used in conjunction with a fuel pump filter for extra protection.

OBJECTIVE 11

Compare and contrast fuel filters used in carbureted type fuel delivery systems and fuel filters used in injector type fuel delivery systems.

Filter Characteristics	Carbureted	Fuel Injected
Filters out fuel contaminants	X	X
Operates at lower pressures	X	
Operates at higher pressures		X
Less rugged design for lower pressure	X	
More rugged design for higher pressure		X
Eliminates only largest particles	X	
Eliminates even smallest particles		X
Requires occasional inspection/replacement	X	
Requires more frequent inspection/replacement		X

☑ **NOTE:** Fuel filters are made of various materials with differing capabilities. Screen filters are made of metal screen and trap only the largest particles. Sintered bronze filters will stop particles as small as 0.0001 inches. Ceramic filters are comparable to bronze. Paper filters are treated with a special resin to stop water as well as contaminants. Saran woven filters look similar to screen filters with smaller openings and are flexible to the touch. They will usually filter water and small solid particles. All of these, except paper filters, can be cleaned. Paper must be discarded and a new paper element installed. Because fuel injection systems operate at higher pressures than carbureted systems, never use a filter designed for a carbureted vehicle in a vehicle with a fuel injected system.

OBJECTIVE 12

Match the names of types of fuel system diagnostic tests to statements describing the tests' purposes.

- **pressure test** — tests the amount of fuel pressure exerted when the fuel exits the fuel pump
- **volume test** — determines the amount of fuel a pump can deliver over a specific amount of time
- **vacuum test** — checks the ability of a pump to pull fuel from the fuel tank through the lines and filters

OBJECTIVE 13 — **Complete Job Sheet 2.**

OBJECTIVE 14 — **Complete Job Sheet 3.**

OBJECTIVE 15 — **List common fuel contaminants.**

Required Activities/
Resources
– Samples of clean and
contaminated fuel

☞ Look at the samples of clean and contaminated fuel in the classroom as your instructor describes the causes of such contamination.

- water

  ☑ **NOTE:** Water is the most common contaminant, and it may also cause other contamination, especially rust.
- rust
- dirt
- excess alcohol

  ☑ **NOTE:** Modern fuels often contain up to 20% alcohol. Higher amounts of alcohol can lead to deterioration of gaskets and hoses causing fuel contamination.

OBJECTIVE 16 — **Complete Job Sheet 4.**

OBJECTIVE 17 — **Complete Job Sheet 5.**

OBJECTIVE 18 — **Complete Job Sheet 6.**

OBJECTIVE 19 — **Complete Job Sheet 7.**

OBJECTIVE 20 — **Complete the Assignment Sheet.**

ASSIGNMENT SHEET

SERVICING FUEL DELIVERY SYSTEMS

8

Name ______________________________ Score __________

OBJECTIVE 20

Diagnose fuel delivery system problems.

INTRODUCTION

The fuel delivery system requires little routine service other than filter changes. However, fuel pumps and carburetor parts wear out, pressure regulators go bad, fuel injectors get dirty, sensors fail, and connectors separate, loosen, or corrode. When these problems occur in the fuel system, they cause problems such as hard starting, hesitation, missing, backfiring, power loss, and surging. The Engine Performance Technician must use specialized knowledge to make an accurate diagnosis of these conditions.

EQUIPMENT AND SUPPLIES

- Handout 1, Carbureted Fuel Delivery System Diagnosis Chart
- Handout 2, Fuel Injected Delivery System Diagnosis Chart
- Job Sheets 1-7

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Cognitive Activities
- Draw conclusions
- Devise a solution
- Transfer knowledge/training to new situations

Review the Handouts and Job Sheets, and use them to help you answer the following questions.

1. While examining a vehicle's oxygen sensor you notice that the tip is a light grey color. Does this suggest a problem and, if so, what is it? What action would you take?

   a. Possible cause: ______________________________

   b. Action: ______________________________

2. A customer complains that his carbureted vehicle backfires. List two possible areas to check.

   - Possible cause: ______________________________

   - Possible cause: ______________________________

Job Acquisition/ Development
- Master specific job task/procedure

3. The carbureted vehicle you are servicing will not start although the engine cranks. List the possible causes you should consider in your diagnosis.

   - Possible cause: ______________________________
   - Possible cause: ______________________________
   - Possible cause: ______________________________

4. The fuel injected vehicle you are diagnosing has low engine power. You are unable to determine when it was last serviced. What should be your first action in determining the cause of the problem?

   ____

5. A customer brings in a fuel injected vehicle and complains that it is very hard to start and has a rough idle. List four possible sources of the problem.

   - Possible cause: ______________________________
   - Possible cause: ______________________________
   - Possible cause: ______________________________
   - Possible cause: ______________________________

6. A friend has a carbureted vehicle, and he complains that when he accelerates the engine hesitates. What is the most probable cause of this problem? What should you check next?

   a. Most probable cause: ___________________________

   b. Next most probable cause: _______________________

7. A customer says his fuel injected delivery vehicle is stalling, surging, and hesitating when he drives it. What three things could be causing these problems?

   - Possible cause: ______________________________
   - Possible cause: ______________________________
   - Possible cause: ______________________________

8. While changing the oil on a carbureted vehicle, you detect fuel in the old engine oil. The customer complained that her vehicle was running in a sluggish manner and was slow to accelerate, so you decide to investigate the cause. What should you examine first to make a diagnosis?

____

9. The carbureted vehicle you are servicing ran unevenly and surged when you test drove it. What are the possible causes of this condition?

- Possible cause: ______________________________
- Possible cause: ______________________________
- Possible cause: ______________________________

10. A customer stated that her vehicle doesn't have much power at high speed. You noticed that it is a carbureted vehicle, so in order to diagnose her problem, what would you check?

- Possible cause: ______________________________
- Possible cause: ______________________________

JOB SHEET 1

SERVICING FUEL DELIVERY SYSTEMS

8

Name ______________________________

OBJECTIVE 7

Inspect, clean, and replace fuel delivery system components.

INTRODUCTION

A variety of factors may prevent the proper operation of a fuel delivery system. Deposits may form on the tip of a fuel injector and prevent the proper fuel delivery and spray pattern, resulting in driveability problems such as rough idle and loss of power and fuel economy. Carbon deposits may build up in the throttle-body bores; even a small amount of carbon may be enough to limit air flow, causing the engine to stall or idle slow and rough. Carbureted systems have many of the same problems and require some of the same procedures as fuel injected systems.

Many fuel delivery system troubles are caused by the filters, fuel lines, vacuum and vapor hoses, fuel pump, carburetor, or fuel injectors. Improper preparation and work habits may create problems that appear after the service work is finished. A major enemy is dirt. A trace of dirt in the wrong place in the fuel system can cause trouble later. So, before beginning any fuel system service, clean your hands, tools, and workbench. A clean, well adjusted fuel induction system is crucial to efficient engine operation.

⚠ **CAUTION:** IN FUEL INJECTION SYSTEMS, the entire system is under very great pressure. Use extreme caution in this highly volatile situation. DO NOT ATTEMPT ANY PROCEDURES WHILE THE SYSTEM IS HOT.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

JOB SHEET 2

SERVICING FUEL DELIVERY SYSTEMS

8

Name ______________________________

OBJECTIVE 13

Inspect, test, and replace fuel pumps, pump control systems, and fuel filters.

Required Activities/ Resources
- Vehicles with fuel pumps in different locations

☞ Look at the different locations on a vehicle where a fuel pump may be installed.

INTRODUCTION

When a vehicle operates in a sluggish manner, is slow to accelerate, or hard to start, always examine the fuel filter first. However, when there is fuel in the engine oil on a carbureted vehicle, the fuel pump should be checked first. Most manufacturers recommend that the fuel filter be changed every 7,500 miles. If the fuel filter is not clogged, the problem may be in the fuel pump. The fuel pump must deliver fuel in both the proper quantity and at the proper pressure for the vehicle's engine to operate efficiently.

There are two basic types of fuel pumps, mechanical and electrical. Mechanical pumps operate from the camshaft and are usually located on one side of the engine block. Electrical pumps are either in-line or tank-mounted. Consult your vehicle service manual to determine the type and location of the pump in your vehicle.

Two fuel pump tests need to be made: pressure, and volume. Fuel pumps are pressure tested in various places depending on the vehicle and the type of fuel pump. For these reasons, it is best to follow only service manual procedures.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	___	___

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

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Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

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EVALUATOR'S COMMENTS

897

JOB SHEET 3 — SERVICING FUEL DELIVERY SYSTEMS — 8

Name ______________________________

OBJECTIVE 14

Inspect, service, repair, and replace air filtration system components.

Required Activities/ Resources
- Different types of air filters
- Vehicles with air cleaners in different locations

☞ Examine different air filters displayed in your classroom.

☞ Look at the different locations where air cleaners may be installed on a vehicle.

INTRODUCTION

Air going to an internal combustion engine must be filtered to screen out dirt or dust which could damage internal engine parts. Manufacturers usually recommend that air filters be replaced every 3,500 miles. If the vehicle is operated in especially dusty or dirty conditions, it may be necessary to replace the filter more often. A clean air filter is essential to proper vehicle operation and long engine life.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 4

SERVICING FUEL DELIVERY SYSTEMS

8

Name ______________________________

OBJECTIVE 16

Remove and replace the fuel tank and fuel gauge sending unit.

Required Activities/
Resources
- Fuel gauge sending unit

☞ Examine a fuel gauge sending unit as your instructor tells you how it may become damaged or nonfunctional.

INTRODUCTION

A fuel tank may need to be replaced because of road damage or because the welded seams have opened. Or it may be contaminated or rusted inside. Generally, the best procedure is to simply replace the tank rather than repairing it. If a decision is made to repair the tank, the work should be done by a shop which specializes in working on fuel tanks.

The fuel gauge sending unit is located inside the tank. It consists of a float which moves up and down with the fuel level, a resistor which varies an electric current depending on the float position, and a wire leading to the fuel gauge. Usually the vehicle owner first notices a problem when the fuel gauge does not show full when the tank is full, or when the fuel gauge does not move as fuel is consumed. The problem is usually in the resistor. A special tester quickly checks the condition of sender and wiring. When the vehicle fuel gauge does not give an accurate reading, it may be necessary to replace the sending unit.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB
SHEET 5

SERVICING FUEL DELIVERY SYSTEMS

Name ______________________________

OBJECTIVE 17

Inspect and replace fuel system components and check fuel condition.

Optional Activities/
Resources in
Instructor's Guide

INTRODUCTION

The fuel system should be inspected any time engine performance or fuel economy drops below normal standards as defined in the service manual or when fuel odors suggest a leak in the system. Components you should inspect include the fuel tank, fuel lines, fuel pump, and fuel filter. If the vehicle has a carburetor, you should inspect it, or if it is fuel injected, inspect the injectors.

Another part of the fuel system is the fuel itself, which may be contaminated. If the fuel filter is dirty or if engine performance is below standards, draw a sample of the fuel from the fuel tank into a clear plastic container using a hand pump or siphon. Allow the container to stand for a few minutes, then look at the contents. Water sinks to the bottom of the container. Anti-freeze floats on top. Dirt or rust sinks and is plainly visible on the bottom of the container.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

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Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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EVALUATOR'S COMMENTS

905

Name ____

OBJECTIVE 18

Test an oxygen sensor.

Required Activities/
Resources
- Explanation
- Oxygen sensors

Listen as your instructor explains problems that can occur because of a malfunctioning oxygen sensor.

Examine the display of oxygen sensors whose tips are the colors indicated below.

INTRODUCTION

An oxygen sensor compares the amount of oxygen in the exhaust with oxygen in the outside air and generates a signal to the engine computer, telling it to make the air-fuel mixture richer or leaner. One type of oxygen sensor has two wires attached. Another type has three wires, one of which provides power to an internal heating element, which helps the sensor reach operating temperature more quickly. The oxygen sensor is one of the most important sensors in a vehicle and, while it has a normal life span of about 50,000 miles, it can become clogged and fail much earlier. Using leaded gasoline in a vehicle designed for unleaded fuel is the most common cause of oxygen sensor failure, although contamination from antifreeze, carbon, or sealants will also shorten its life.

An examination of the oxygen sensor tip may provide clues to possible problems. Use the following chart to make your diagnosis.

Sensor Tip Color	Contamination	Action
Light grey	None	Reinstall sensor.
White	Silicon	Replace sensor.
Tan	Lead	Clean by running engine lean or replace.
Black	Carbon	Wipe carbon off, determine source.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

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Product meets performance requirements	4	3	2	1
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AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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EVALUATOR'S COMMENTS

JOB SHEET 7 — SERVICING FUEL DELIVERY SYSTEMS

Name ______________________________

OBJECTIVE 19

Remove and replace an oxygen sensor.

INTRODUCTION

The oxygen sensor is located somewhere in the exhaust stream of the vehicle. The appropriate service manual gives you the exact location and also identifies the type of sensor installed on the vehicle.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

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EVALUATOR'S COMMENTS

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OBJECTIVE SHEET

SERVICING FUEL INJECTION SYSTEMS

9

INTRODUCTION

Fuel injection has many advantages over the carbureted fuel systems, but cost, environmental conditions, and complexity limited their use. In the late '70s, the need to comply with stricter government fuel efficiency standards and a rapid expansion of the electronics industry resulted in fuel injection systems replacing carbureted fuel delivery systems in all vehicles.

Fuel injection systems represent the most precise fuel systems ever developed for the automobile. A precision system requires precision care. Learning fuel injection systems and how to service them takes time, effort, and some specialized tools. An Engine Performance Technician needs to understand, diagnose, and correct any problems associated with the fuel injection system.

PREREQUISITE

Unit 8, "Servicing Fuel Delivery Systems"

FOCUS ASSIGNMENTS

FOCUS ASSIGNMENTS

PREREADING:	Read Don Chaikin's article, "How It Works, Fuel Injection," *in Popular Mechanics* magazine, August 1991, p. 68.
WRITING:	Write one or two paragraphs that describes the fuel delivery system of a fuel injection engine.

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment Sheet and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. Name the two types of fuel injection systems shown in illustrations.
2. State the method of fuel induction for each type of fuel injection system.
3. State the number and placement of injectors in each type of fuel injection system.
4. Match the names of the two ways fuel injection systems are controlled with descriptions of their control.
5. Match the names of methods of sequencing injectors with descriptions of the sequence.
6. Label the parts of a fuel injector indicated on an illustration.
7. Match the names of engine monitoring and control devices which assist in fuel injection system operation with descriptions of the conditions they monitor or control.
8. Match the names of the operating conditions of a fuel injector to descriptions of the injector's operation during each condition.
9. State the function of an idle speed control system.
10. Describe the operation of an idle speed control system.
11. State the function of a cold start enrichment system.
12. Arrange the steps of cold start enrichment system operation in order.
13. State the function of an acceleration enrichment system.
14. Describe the operation of an acceleration enrichment system.
15. State the function of a fuel pressure regulation system.
16. Describe the operation of a fuel pressure regulation system.
17. Describe the operation of a deceleration control system.
18. Check and adjust the fuel injection idle speed and fuel mixture on a closed-loop fuel control system. (Job Sheet 1)
19. Inspect, test, adjust, and replace components of an idle speed control system. (Job Sheet 2)

20. Remove, clean, inspect, test, repair, and replace vacuum and electrical components and connections of a fuel injection system. (Job Sheet 3)

21. Inspect, test, repair, and replace components of a fuel pressure regulation system. (Job Sheet 4)

22. Verify engine operating temperature. (Job Sheet 5)

23. Inspect, test, adjust, repair, and replace a fuel injection cold start enrichment system. (Job Sheet 6)

24. Inspect, test, adjust, and replace an acceleration enrichment system and components. (Job Sheet 7)

25. Test the operation of a deceleration control system. (Job Sheet 8)

26. Inspect, test, and replace a deceleration fuel reduction or shut off system and components. (Job Sheet 9)

27. Name the two fuel injector tests which test for clogged fuel injectors.

28. Describe the test procedures for these two fuel injector tests.

29. Perform fuel injector tests. (Job Sheet 10)

30. Inspect, clean, and replace fuel injectors, and clean a fuel injection system. (Job Sheet 11)

31. Diagnose fuel injection performance problems. (Assignment Sheet)

OBJECTIVE 1

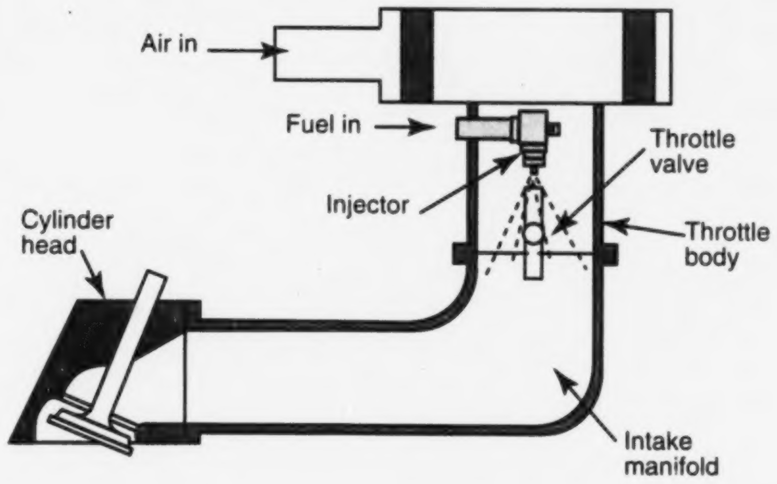
Required Activities/ Resources
- Transparency Masters 1 and 2

Name the two types of fuel injection systems shown in illustrations.

Look at transparencies 1 and 2 as your instructor explains the operation of the two types of fuel injection systems.

- **throttle body fuel injection system**

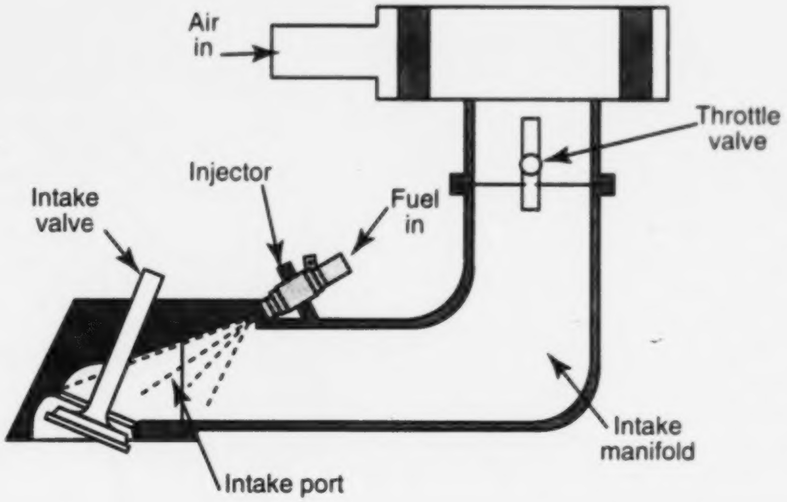
FIGURE 1


Air in
Fuel in
Throttle valve
Injector
Cylinder head
Throttle body
Intake manifold

NOTE: Gasoline fuel injection systems are either the *throttle body* type or the *port* type while all diesel fuel injection systems are the *port* type.

- **port fuel injection system**

FIGURE 2



OBJECTIVE 2

State the method of fuel induction for each type of fuel injection system.

- **throttle body fuel injection system** — fuel is sprayed into the engine intake manifold

☑ **NOTE:** This is called the *indirect* method of induction.

- **port fuel injection system** — fuel is sprayed into the intake ports of each cylinder

☑ **NOTE:** This is called the *direct* method of induction.

OBJECTIVE 3

State the number and placement of injectors in each type of fuel injection system.

- **throttle body fuel injection system** — one or two injectors are mounted on the throttle body assembly and spray fuel into the top center of the intake manifold

☑ **NOTE:** This is called *single-point* placement.

- **port fuel injection system** — an injector in the intake port of each cylinder sprays fuel into the intake port

  ☑ **NOTE:** This is called *multi-port* placement.

OBJECTIVE 4

Match the names of the two ways fuel injection systems are controlled with descriptions of their control.

- **electronic fuel injection** — uses sensors and the engine computer to control the opening and closing of the fuel injectors
- **mechanical fuel injection** — uses a throttle linkage, a mechanical pump, and a governor speed device to control the opening and closing of the fuel injectors

  ☑ **NOTE:** Most gasoline fuel injection systems are *electronic.*

OBJECTIVE 5

Match the names of methods of sequencing injectors with descriptions of the sequence.

- **modulated** — opens and closes the needle of the injector independently of the engine intake valves and can spray fuel into the engine when the valves are open or when they are closed
- **sequential** — sprays fuel into the intake port right before or as the intake valves open
- **continuous** — sprays fuel into the intake manifold all of the time

OBJECTIVE 6

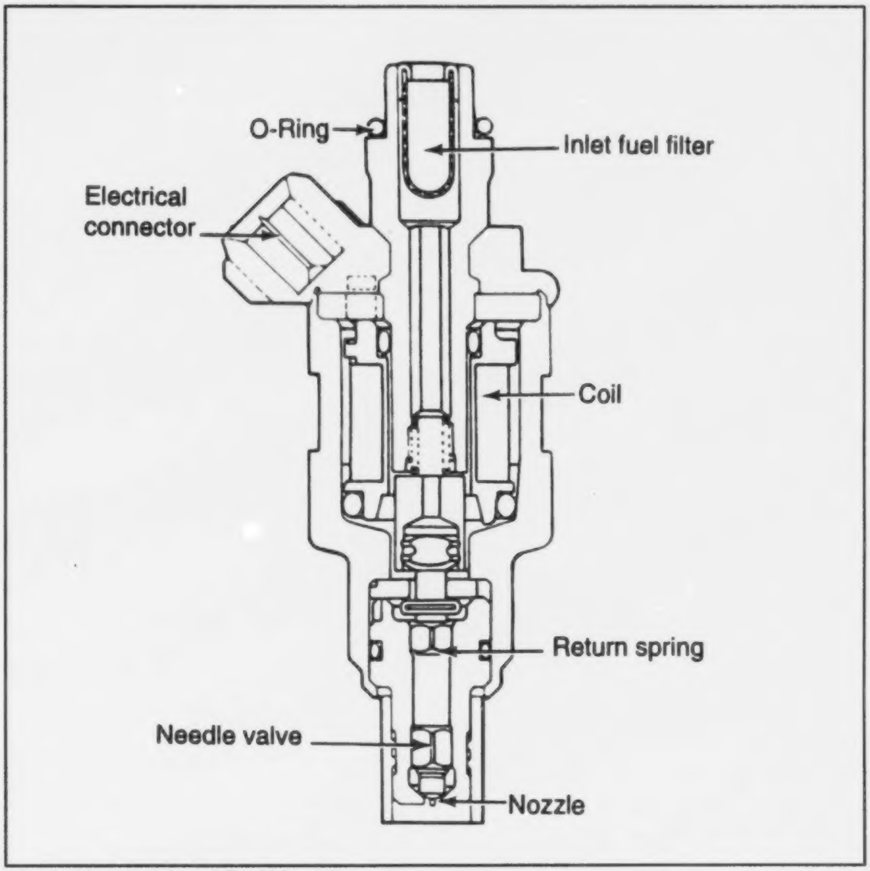
Required Activities/
Resources
– Transparency Master 3
– Fuel injectors

Label the parts of a fuel injector indicated on an illustration.

Look at transparency 3 as your instructor explains how a fuel injector works.

Examine actual fuel injectors as they are passed around the classroom.

FIGURE 3


O-Ring
Inlet fuel filter
Electrical connector
Coil
Return spring
Needle valve
Nozzle

Used with permission of Ford Motor Co.

☑ **NOTE:** Throttle body fuel injectors are generally larger than port fuel injectors.

OBJECTIVE 7

Match the names of engine monitoring and control devices which assist in fuel injection system operation with descriptions of the conditions they monitor or control.

WORDS YOU SHOULD KNOW	
cold-start	the engine is cold when started
enrich	to add fuel to the air-fuel mixture thereby increasing engine power
lean	to decrease the amount of fuel in the air-fuel mixture thereby decreasing engine power

- **airflow sensor** — measures the volume of air flowing into the intake manifold so the correct air-fuel mixture can be maintained

  ☑ **NOTE:** The airflow sensor is located in the air intake system between the air cleaner and the throttle valve.

- **fuel pressure regulator** — regulates the amount of pressure entering the injector

  ☑ **NOTE:** Under load conditions the fuel pressure regulator will allow the pressure to the injector to remain stable.

- **manifold absolute pressure (MAP) sensor** — monitors the vacuum in the intake manifold so the air-fuel mixture can be enriched or leaned with changes in engine load

- **thermo-time switch** — senses the temperature of the engine coolant and allows or inhibits the firing of the cold start injector

  ☑ **NOTE:** During cranking, electricity from the battery flows to the thermo-time switch. If the coolant temperature is below manufacturer's specifications, the thermo-time switch closes and allows the electricity to fire the cold start injector. Cold start enrichment systems, including thermo-time switches, are found only on some port fuel injection systems. The starter solenoid is either remote or attached to the starter.

- **throttle position sensor (TPS)** — senses movement of the throttle valve so the air-fuel mixture can be adjusted for engine speed, acceleration, and deceleration

  ☑ **NOTE:** The opening and closing of the throttle valve is controlled when the driver pushes or lets up on the accelerator pedal.

OBJECTIVE 8

Match the names of the operating conditions of a fuel injector to descriptions of the injector's operation during each condition.

WORDS YOU SHOULD KNOW	
pulse width	the amount of time each injector is kept open. When the amount of time the injector is kept open is increased, there is more fuel in the air-fuel mixture (it is enriched), causing an increase in power.

- **start** — the pulse width is increased
- **idle** — the pulse width is decreased
- **acceleration** — the pulse width is increased
- **cruise** — the minimum pulse width is maintained for the load, speed, temperature, and other operating variables
- **deceleration** — the pulse width is decreased

OBJECTIVE 9

State the function of an idle speed control system.

An idle speed control system prevents changing engine load from stalling the engine.

☑ **NOTE:** Engine load changes during idling when the vehicle is put in gear, when the air conditioning is turned on, or during other similar activities.

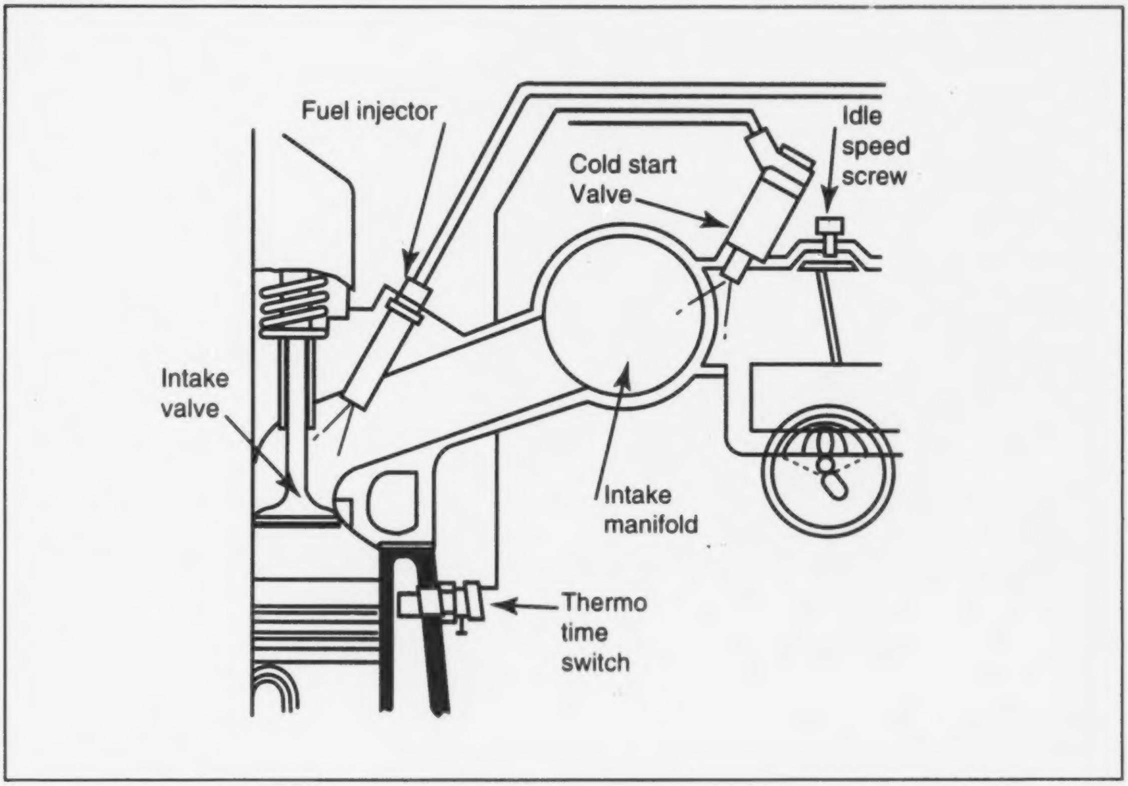
OBJECTIVE 10

Describe the operation of an idle speed control system.

Engine sensors detect changing load during idle and send this information to the engine computer. The engine computer directs the idle air control motor to move the idle air control valve, allowing air to pass around the throttle valve. The airflow sensor detects the additional air flow and makes the adjustment to increase idle speed, preventing stalling. (Figure 4)

EXAMPLE:

FIGURE 4


Fuel injector
Idle speed screw
Cold start Valve
Intake valve
Intake manifold
Thermo time switch

☑ **NOTE:** The idle air control motor and idle air control valve are located in the throttle body.

OBJECTIVE 11

State the function of a cold start enrichment system.

A cold start enrichment system aids cold engine starting by supplying extra fuel to enrich the air-fuel mixture.

☑ **NOTE:** Cold start enrichment systems are only found on some port fuel injection systems.

OBJECTIVE 12

Arrange the steps of cold start enrichment system operation in order.

1. The driver cranks the engine.
2. The starter solenoid begins a flow of electricity to the thermo-time switch.

3. The thermo-time switch detects a cold engine.

4. The thermo-time switch closes, allowing the electricity to start the cold start injector.

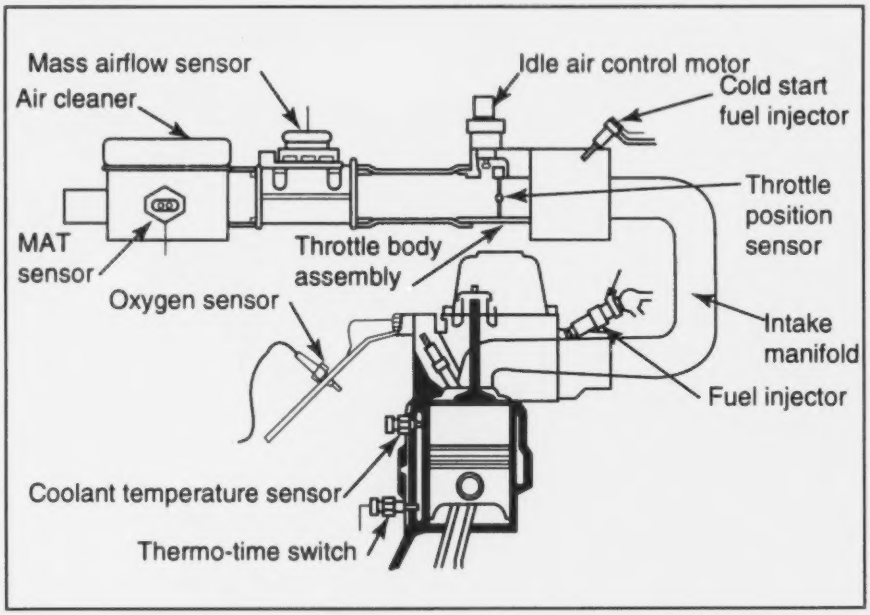
5. The cold start injector sprays fuel into the intake manifold, and the other injectors spray fuel into the intake ports to enrich the air-fuel mixture during cranking.

6. The thermo-time switch shuts down the cold start injector after 10-12 seconds when the engine warms up or the preset time is past.

   ☑ **NOTE:** The cold start enrichment system operates only during cranking.

EXAMPLE:

FIGURE 5


Mass airflow sensor
Idle air control motor
Air cleaner
Cold start fuel injector
Throttle position sensor
MAT sensor
Throttle body assembly
Oxygen sensor
Intake manifold
Fuel injector
Coolant temperature sensor
Thermo-time switch

OBJECTIVE 13

State the function of an acceleration enrichment system.

An acceleration enrichment system increases engine power needed for acceleration by enriching the air-fuel mixture.

OBJECTIVE 14

Describe the operation of an acceleration enrichment system.

The throttle position sensor and the manifold absolute pressure sensor signal the engine computer that acceleration should begin.

The engine computer increases the pulse width of the injectors, the air-fuel mixture is enriched, and the engine power for acceleration is increased.

OBJECTIVE 15

Optional Activities/
Resources in
Instructor's Guide

State the function of a fuel pressure regulation system.

A fuel pressure regulation system maintains a uniform amount of pressure at the fuel injector to assure its proper operation.

☑ **NOTE:** A fuel pressure regulator in the system controls the amount of pressure at the injector. The regulator returns any unused fuel to the fuel tank.

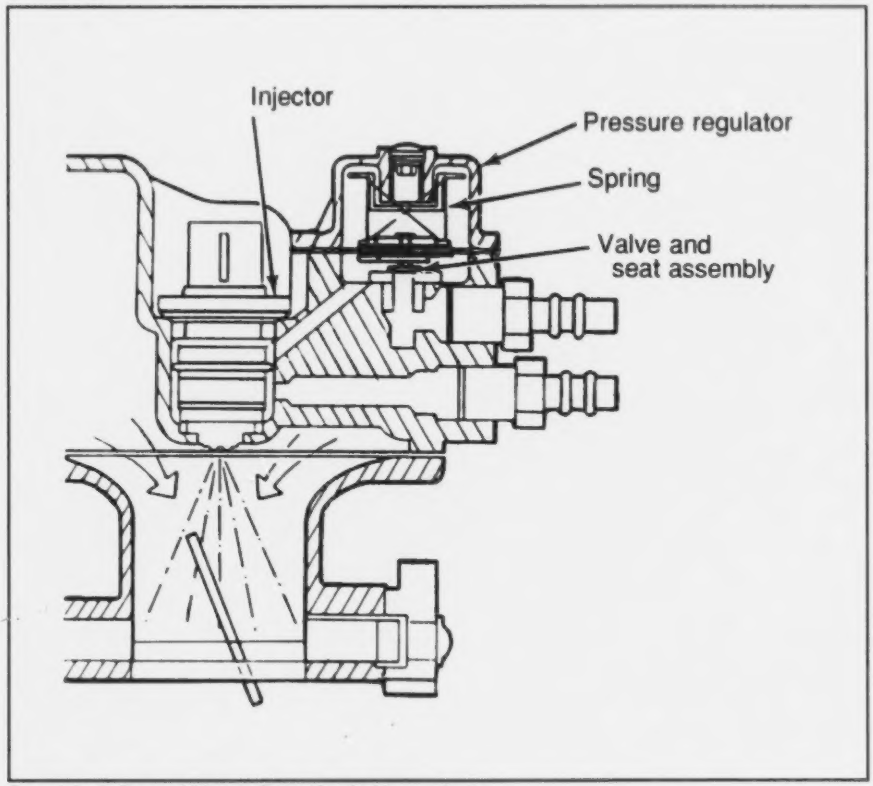
OBJECTIVE 16

Describe the operation of a fuel pressure regulation system.

The fuel pressure regulator is constructed to respond to manifold vacuum pressure to allow the appropriate amount of pressure at the injector. (Figure 6)

EXAMPLE:

FIGURE 6



Copyright © General Motors Corp. Used with permission.

OBJECTIVE 17 **Describe the operation of a deceleration control system.**

The throttle position sensor and the manifold absolute pressure sensor signal the engine computer that deceleration should begin. The engine computer decreases the pulse width of the injectors, the air-fuel mixture is leaned, and the engine power is reduced, causing deceleration.

OBJECTIVE 18 **Complete Job Sheet 1.**

OBJECTIVE 19 **Complete Job Sheet 2.**

OBJECTIVE 20 **Complete Job Sheet 3.**

OBJECTIVE 21 **Complete Job Sheet 4.**

OBJECTIVE 22 **Complete Job Sheet 5.**

OBJECTIVE 23 **Complete Job Sheet 6.**

OBJECTIVE 24 **Complete Job Sheet 7.**

OBJECTIVE 25 **Complete Job Sheet 8.**

OBJECTIVE 26 **Complete Job Sheet 9.**

OBJECTIVE 27 **Name the two fuel injector tests which test for clogged fuel injectors.**

- injector spray pattern test
- injector drop test

☑ **NOTE:** The injector drop test is only made on port fuel injector systems.

OBJECTIVE 28 **Describe the test procedures for these two fuel injector tests.**

Optional Activities/
Resources in
Instructor's Guide

- **injector spray pattern test** — a visual inspection is made of the pattern made by the gasoline spray coming out of the nozzle of the injector during operation. An abnormal spray pattern indicates the injector is clogged.

  ☑ **NOTE:** The pattern should be a fine cone-shaped mist.

- **injector drop test** — a fuel pressure gauge is used to measure the fuel pressure as each injector is sprayed individually. Any drop in pressure indicates the injector is clogged.

OBJECTIVE 29 **Complete Job Sheet 11.**

OBJECTIVE 30 **Complete Job Sheet 12.**

OBJECTIVE 31 **Complete the Assignment Sheet.**

ASSIGNMENT SHEET

SERVICING FUEL INJECTION SYSTEMS

9

Name ______________________________ Score __________

OBJECTIVE 31

Diagnose fuel injection performance problems.

EQUIPMENT AND SUPPLIES

- Handout 3, Preliminary Checklist for Fuel Injection Diagnosis
- Handout 4, Throttle Body Fuel Injection System Diagnosis Chart
- Handout 5, Port Fuel Injection Diagnosis Chart

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

General Science
- Investigate/apply technology

Cognitive Activities
- Draw conclusions
- Transfer knowledge/training to new situations

Job Acquisition/Development
- Master specific job task/procedure

Use Handouts 3-5 to help you answer the following questions. Put the letter of the answer in the blank to the left.

_____ 1. A bleeding injector in a throttle body type system is considered a possible cause of hard start when the engine is hot. What corrective action should be taken?

A. Inspect the fuel pressure regulation system.
B. Inspect the injector for dripping; service or replace as required.
C. Check for fuel leak or defective fuel pump.
D. Check the fuel lines for restrictions.

_____ 2. Technician A says that a defective fuel pump can cause problems with the fuel injection system. Technician B says a fuel injection system has its own fuel pressure regulator and does not rely on the fuel pump. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____ 3. What fuel injection system problem would you look for first if your engine had poor power?

A. Fuel filter
B. Manifold absolute pressure
C. Fuel pump
D. None of the above

____ 4. Which of the following is *not* considered a preliminary checks in determining fuel injection problems?

A. Check the fuel system for fuel leaks.
B. Start the engine and let it warm up before putting the computer through the self-test mode.
C. Check all wiring and connections.
D. Check the vacuum hoses.

____ 5. A vehicle with a throttle body type fuel injection system is stalling. Which of the following should be done in diagnosing the problem?

A. Check idle speed control device.
B. Check the air cleaner.
C. Check the fuel filter.
D. All of the above

____ 6. Technician A suspects the fuel line is restricted and Technician B suspects a fuel system leak causing the hard start problems of a vehicle. What should be the first action?

A. Make a preliminary check .
B. Replace the fuel pump.
C. Check the computer for date of last service.
D. Check the fuel pump pressure.

____ 7. Which of the following could cause a hard start in a port fuel injection engine that is starting cold?

A. Bad oxygen sensor
B. Fuel leak
C. Defective idle speed control system
D. Bad cold start injector

____ 8. Technician A says that a low coolant level can cause symptoms similar to those caused by a defective fuel injection system. Technician B says that a low battery can cause symptoms similar to those caused by a bad fuel injection system. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____ 9. What performance problem could be caused by a defective coolant temperature sensor?

A. Hard start
B. Overheating
C. Restricted exhaust
D. None of the above

_____ 10. What is the corrective action if an oxygen sensor is not functioning properly?

A. Clean.
B. Adjust.
C. Repair.
D. Replace.

JOB SHEET 1

SERVICING FUEL INJECTION SYSTEMS

9

Name ______________________________

OBJECTIVE 18

Check and adjust the fuel injection idle speed and fuel mixture on a closed-loop fuel control system.

Required Activities/ Resources
- Scan tool or engine computer analyzer
- Explanation

Look at a scan tool and/or an engine computer analyzer as your instructor reviews their operation.

Listen to your instructor's explanation of closed-loop and open-loop control systems.

INTRODUCTION

A closed-loop fuel control system refers to an electronically controlled fuel injection system that uses information from the oxygen sensor and other sensors to control the air-fuel mixture. In theory, a complete loop is formed as signals flow from the sensors to the engine computer and back to the fuel injection system. When the engine is cold, the system is in open-loop. The computer operates on stored data, not on information from sensors. After the engine warms up, the oxygen sensor can function and send data to the computer; however, under most operating conditions, an electronic fuel injection system functions in closed-loop. This allows the computer to double check the fuel mixture it is providing to the engine.

Some electronic fuel injection systems have self-test abilities that can detect a bad component. They will produce a code that will pinpoint the problem. If an adjustment is indicated, refer to the appropriate service manual to interpret the code and reference the correct adjustment procedure. Always be sure that the engine is fully warmed up before entering the self-test mode. Vehicles that do not have a self-test function will require special tools to check the operation.

EQUIPMENT AND SUPPLIES

- Vehicle with an electronic fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 2

SERVICING FUEL INJECTION SYSTEMS

Name ______________________________

OBJECTIVE 19

Inspect, test, adjust, and replace components of an idle speed control system.

Required Activities/Resources
- Vehicle with an idle speed control system

Look at the components of an idle speed control system on an actual vehicle.

INTRODUCTION

Inspections of an idle speed control system are usually performed only after or during major fuel injection servicing operations. When inspecting the components of an idle speed control system, always start with a visual inspection. Check for an open plug wire or burned valve before proceeding any further. Test to make sure the throttle cable is correctly adjusted. If the idle air control valve is bad, it must be replaced. If the idle air control motor is bad, it may be serviceable. If you replace any parts, always check fuel injection system operation after installation.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

Name ______________________________

OBJECTIVE 20

Remove, clean, inspect, test, repair, and replace vacuum and electrical components and connections of a fuel injection system.

Required Activities/
Resources
– Explanation

Listen as your instructor explains why vacuum leaks are a common and critical source of problems with the fuel injection system.

INTRODUCTION

The vacuum system on vehicles with fuel injection must be very tight or problems may develop. Every single source related to the engine where a vacuum leak may occur — even if you think it has nothing to do with the injection system directly — must be checked thoroughly to eliminate it as the source of a problem. Even a dipstick pulled part way out could create a problem.

Vacuum and electrical components will vary with the vehicle, but some basic guidelines will give you an idea what to expect.

Inspection Guidelines:

- Inspect the engine compartment for leaking hoses and vacuum leaks.
- Look for kinked lines, fuel leaks, and loose electrical connections.
- Inspect the wiring harnesses and connectors for rust, corrosion, or burning.
- Always pull the connectors apart to check the metal pins and tabs for corrosion.
- When you pull the connectors apart, never pull on the wires or wiring harness, only on the connectors.
- Check all electrical connections to sensors and fuel injectors by wiggling or shaking the connections to ensure they are tight.
- Inspect periodically with regular scheduled maintenance.

Testing Guidelines:

- Test for high resistance at terminal connections. It is a frequent cause of problems.

- Before testing, always check the computer's memory carefully. It may have stored codes that will be useful to your diagnosis.
- Clear old codes. It is not unusual to find trouble codes that were left over from a previous repair.
- Once the computer's memory has been cleared, drive for at least five minutes and then check to see if any codes reset.
- If no trouble codes are found do not assume the electrical system is all right until a performance test is made and some of the essential sensor inputs checked.
- If trouble codes do exist, always refer to the appropriate service manual

☑ **NOTE:** Many problems will not set a trouble code. Problems of this type are often referred to as a *gray area* because they do not fit neatly into any diagnostic charts. To diagnose these problems, special instruments or tools may be required. Refer to the appropriate service manual for the appropriate tools and correct procedure.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 4

SERVICING FUEL INJECTION SYSTEMS

9

Name ____

OBJECTIVE 21

Inspect, test, repair, and replace components of a fuel pressure regulation system.

INTRODUCTION

Procedures will vary with the vehicle, but these basic guidelines will help you understand the methods in the service manual.

Guidelines:

- Begin by checking the operation of the fuel pump. With the key on, listen to pump operation. The pump should run for a few seconds and shut off. If the fuel pump does not run with the key on, test for voltage with a test light or voltmeter.
- Check the fuel pump fuse, related wiring, pump relay, and inertia switch. The problem is usually a burnt relay when there is a hard start problem.
- Check other possible problems such as a clogged fuel filter or smashed return line before testing the fuel pressure regulator.
- When testing the fuel pressure regulator, install a pressure gauge at the test fitting on the fuel rail or before the regulator.
- Although the pressure regulator is tested while the system is under pressure, you must relieve fuel pressure in a vehicle with electronic fuel injection if you replace the component.

CAUTION: IN FUEL INJECTION SYSTEMS, THE ENTIRE FUEL SYSTEM IS UNDER VERY GREAT PRESSURE. Use extreme caution in this highly volatile situation. DO NOT ATTEMPT ANY PROCEDURES WHILE THE SYSTEM IS HOT.

- Look for a special relief valve for bleeding the pressure back to the fuel tank. If the vehicle does not have a special relief valve, remove the fuse for the fuel pump, start and idle the engine, and when the engine stalls, the pressure has been removed from the system.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS ____

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JOB SHEET 5 — SERVICING FUEL INJECTION SYSTEMS

Name ______________________________

OBJECTIVE 22

Verify engine operating temperature.

Required Activities/
Resources
- Digital multimeter

Listen as your instructor reviews the ohmmeter function of a digital multimeter.

INTRODUCTION

In an electronic fuel injection system, if the coolant temperature sensor and/or the inlet air temperature sensor is defective, the engine may run rich or lean. The internal resistance of these sensors changes with the temperature. The ohmmeter function of a digital multimeter is often used for testing these temperature sensors.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 6

SERVICING FUEL INJECTION SYSTEMS

9

Name ____

OBJECTIVE 23

Optional Activities/
Resources in
Instructor's Guide

Inspect, test, adjust, repair, and replace a fuel injection cold start enrichment system.

INTRODUCTION

Parts of the cold start enrichment system include the cold start injector, the thermo-time switch, the starter solenoid, the battery, and the wiring that connects these components. Each of these will have to be inspected and tested in order to locate a problem with the system. These procedures will vary from vehicle to vehicle, but remember, cold start enrichment systems are only found in vehicles with port fuel injection systems and, even then, only with some, not all, port systems.

EQUIPMENT AND SUPPLIES

- Vehicle with a cold start enrichment system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
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EVALUATOR'S COMMENTS

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JOB SHEET 7

SERVICING FUEL INJECTION SYSTEMS

9

Name ______________________________

OBJECTIVE 24

Inspect, test, adjust, and replace an acceleration enrichment system and components.

INTRODUCTION

A single system involving several components controls the acceleration, cruise, and deceleration functions of a fuel injection system. The system is tested as a whole, and, if it does not work, it is replaced. The service manual will give you the procedure for performing this evaluation on the vehicle you are servicing, but these guidelines will give you some help.

Guidelines:

- Look at electrical connections for loose or worn wires.
- Check the gaskets around the intake manifold and the fuel pressure regulation system for leaks.
- Visually inspect the linkage of the throttle and connections for wear and corrosion.
- Check to make sure the throttle valve responds to the gas pedal when it is depressed.
- Check the throttle position sensor for correct readings.
- If the electronic self-test reveals a problem with the throttle position sensor, use the ohmmeter function of a digital multimeter to determine the condition of the throttle position sensor.
- In checking other sensors in an electronic fuel injection system, use the self-test mode of the engine computer, special analyzers, or a digital multimeter as required.
- Visual inspection of the components of an acceleration enrichment system should be performed at regular scheduled maintenance inspections.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 8

SERVICING FUEL INJECTION SYSTEMS

Name ______________________________

OBJECTIVE 25

Test the operation of a deceleration control system.

INTRODUCTION

When testing the operation of a deceleration control system, you will make the same sort of checks you made for the acceleration control system.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 9

SERVICING FUEL INJECTION SYSTEMS

9

Name ____

OBJECTIVE 26

Inspect, test, and replace a deceleration fuel reduction or shut off system and components.

INTRODUCTION

Deceleration fuel reduction or shut off systems are found on some vehicles which have modulated or continuous injector sequencing. With these types of sequencing, it sometimes happens that the injectors have sprayed a large amount of fuel into the engine just before deceleration begins. With a large amount of fuel and not enough air, the engine can flood. Deceleration fuel reduction or shut off systems prevent this from happening.

The design of deceleration fuel reduction or shut off systems varies widely from model to model. Some systems work before the air-fuel mixture is inducted into the cylinder. Some work when the mixture is exhausted into the exhaust manifold. The methods of inspecting, testing, and replacing a system will be found in the appropriate service manual.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 10 — *SERVICING FUEL INJECTION SYSTEMS* — 9

Name ____________________

OBJECTIVE 29 **Perform fuel injector tests.**

INTRODUCTION

Engine Performance Technicians almost never make injector spray pattern tests. Although examination of the pattern could tell you if the injector is clogged, the danger involved with spraying fuel is too great to justify the technique. Few shops have the equipment or controlled environment which would make the test safe.

Injector drop tests are made on port fuel injection systems. A fuel pressure gauge is connected to the fuel rail, and each injector is fired manually. If the fuel pressure on any injector drops more than the pressure on other injectors, that injector is clogged.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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950

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 11

SERVICING FUEL INJECTION SYSTEMS

Name ______________________________

OBJECTIVE 30

Inspect, clean, and replace fuel injectors, and clean a fuel injection system.

INTRODUCTION

If you suspect that a fuel injector is leaking, you can usually see evidence of the leak, but if not, listen for hissing sounds or use oil to help locate suspected leaking areas. A chemical flush is usually run through the injector system to clean it, but the service manual will give you specific instructions on the advisability of such a practice. If a flush is used, be sure to block the fuel lines and disable the fuel pump before running the solvent through the system. If a fuel injector is clogged, in modern practice it is not cleaned, it's replaced.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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952

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

OBJECTIVE SHEET

SERVICING TURBOCHARGER SYSTEMS

10

INTRODUCTION

An engine can produce more power with each power stroke if each cylinder contains more air-fuel mixture. A turbocharger is basically an air compressor. It is used to increase the amount of air in the engine cylinders. Instead of being drawn in by a vacuum created in the cylinders (the process in engines without a turbocharger) the air in a turbocharged engine is compressed into each cylinder and mixed with a proportionately higher amount of fuel. This dense mixture, or charge, is then ignited.

When more air-fuel mixture can be compressed into the cylinders, the power output of the engine is increased. This additional horsepower, 35-60% more than in a non-turbocharged engine of the same size, is commonly considered useful during acceleration but can also be helpful when the vehicle needs to pull greater loads. Also, because a greater amount of air is present to support combustion, there is a more complete burning of the air-fuel mixture. This reduces harmful exhaust emissions over the size engine they replace. Turbocharged engines require higher octane fuel than engines without turbochargers. Using low octane fuel in a turbocharged engine will cause preignition.

PREREQUISITE

Unit 9, "Servicing Fuel Injection Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS

PREREADING:	Read about how turbochargers/superchargers affect engine performance in Mac DeMere's article, "Toyota Supra Turbo," in *Motor Trend* magazine, March 1993, pp. 54-57.
WRITING:	Write a short (one paragraph to one page) comparison of turbocharged/supercharged vehicles to non-turbocharged/supercharged vehicles of the same class. Include any examples of vehicles equipped with twin turbos and any effect on engine response time.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. State the function of a turbocharger/supercharger.
2. Label the parts of a turbocharger indicated on an illustration.
3. Match the names of the parts of a turbocharger to descriptions of their functions.
4. List the reasons why lubrication is important for a turbocharger.
5. Test the operation of a turbocharger system. (Job Sheet 1)
6. Remove, clean, inspect, repair, and replace turbocharger system components. (Job Sheet 2)
7. Identify the causes of turbocharger failure. (Assignment Sheet 1)
8. Label the parts of a supercharger indicated on an illustration.
9. Match the names of the parts of a supercharger to descriptions of their functions.
10. Compare and contrast a turbocharger and a supercharger.
11. Test the operation of a supercharger system. (Job Sheet 3)
12. Remove, clean, inspect, repair, and replace supercharger system components. (Job Sheet 4)
13. Identify the causes of supercharger failure. (Assignment Sheet 2)

INFORMATION SHEET | *SERVICING TURBOCHARGER SYSTEMS* 10

OBJECTIVE 1

Required Activities/
Resources
– Explanation

Optional Activities/
Resources in
Instructor's Guide

State the function of a turbocharger/supercharger.

Listen to your instructor's explanation of the function of a turbocharger/supercharger.

A turbocharger or supercharger increases engine power by forcing more air-fuel mixture into the engine's cylinders prior to combustion.

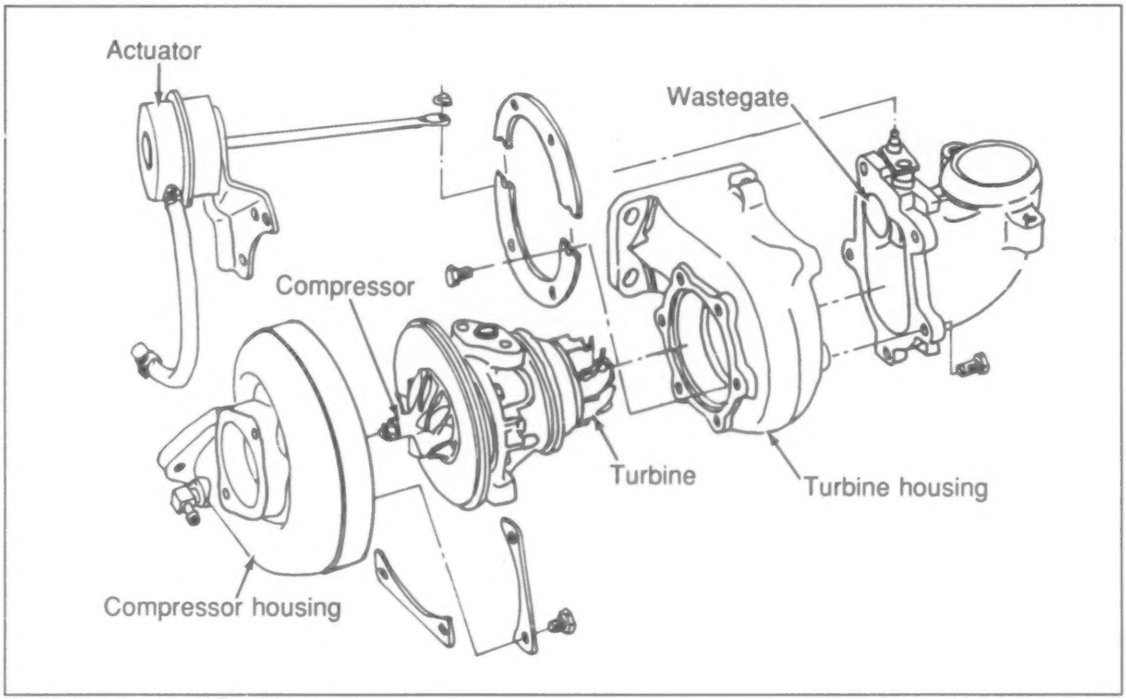
OBJECTIVE 2

Required Activities/
Resources
– Turbocharger parts

Label the parts of a turbocharger indicated on an illustration.

Examine the parts of an actual turbocharger.

FIGURE 1



Used with permission of Ford Motor Co

NOTE: A turbocharger is usually bolted to the side or top of the engine. Exhaust tubing directs the engine exhaust gases to the turbine housing, and connecting tubes or hoses direct the air-fuel mixture to the intake manifold.

OBJECTIVE 3

Required Activities/ Resources
- Transparency Master 1

Optional Activities/ Resources in Instructor's Guide

Match the names of the parts of a turbocharger to descriptions of their functions.

Look at transparency 1 as your instructor describes the function of each part of a turbocharger.

- **actuator** — opens and closes the wastegate in response to intake manifold pressure

  ☑ **NOTE:** Without the actuator, there is no control over the amount of air being packed into the intake manifold, and the pressure could eventually exceed the maximum for which the engine was designed, causing the engine to explode.

- **compressor** — forces air into the intake manifold

  ☑ **NOTE:** Increased density of the intake mixture results in an increase in engine power. This increased engine power is called *boost*.

- **compressor housing** — contains and protects the compressor
- **turbine** — a fan-bladed wheel, turned by exhaust gases, which powers the compressor

  ☑ **NOTE:** Notice that the compressor and turbine share a common shaft. (Figure 1)

- **turbine housing** — contains and protects the turbine
- **wastegate** — channels excess exhaust gases away from the turbine

OBJECTIVE 4

Required Activities/ Resources
- Explanation
- Damaged turbocharger parts

List the reasons why lubrication is important for a turbocharger.

Listen as your instructor explains the importance of turbocharger lubrication.

Look at actual turbocharger parts that have been damaged from improper lubrication.

- Reduces friction at high rotational speeds
- Cools parts

- Reduces expansion of metal parts

  ☑ **NOTE:** Turbocharger parts are often made with different types of metals. When heat is generated during turbocharger operation, these metals expand at different rates causing the parts to seize up. Therefore, it is critical that turbochargers remain lubricated at all times. Lubrication occurs when engine oil is line-fed to the turbocharger oil inlet. The oil enters the turbocharger under engine pressure, flows through the turbocharger bearings, and drains back to the engine through an oil drain line. This allows the turbocharger to be lubricated during operation and protects the shaft and bearings from damage. Although turbochargers are supplied with oil through the regular engine lubrication system, oil especially recommended for turbochargers should be used.

OBJECTIVE 5 **Complete Job Sheet 1.**

OBJECTIVE 6 **Complete Job Sheet 2.**

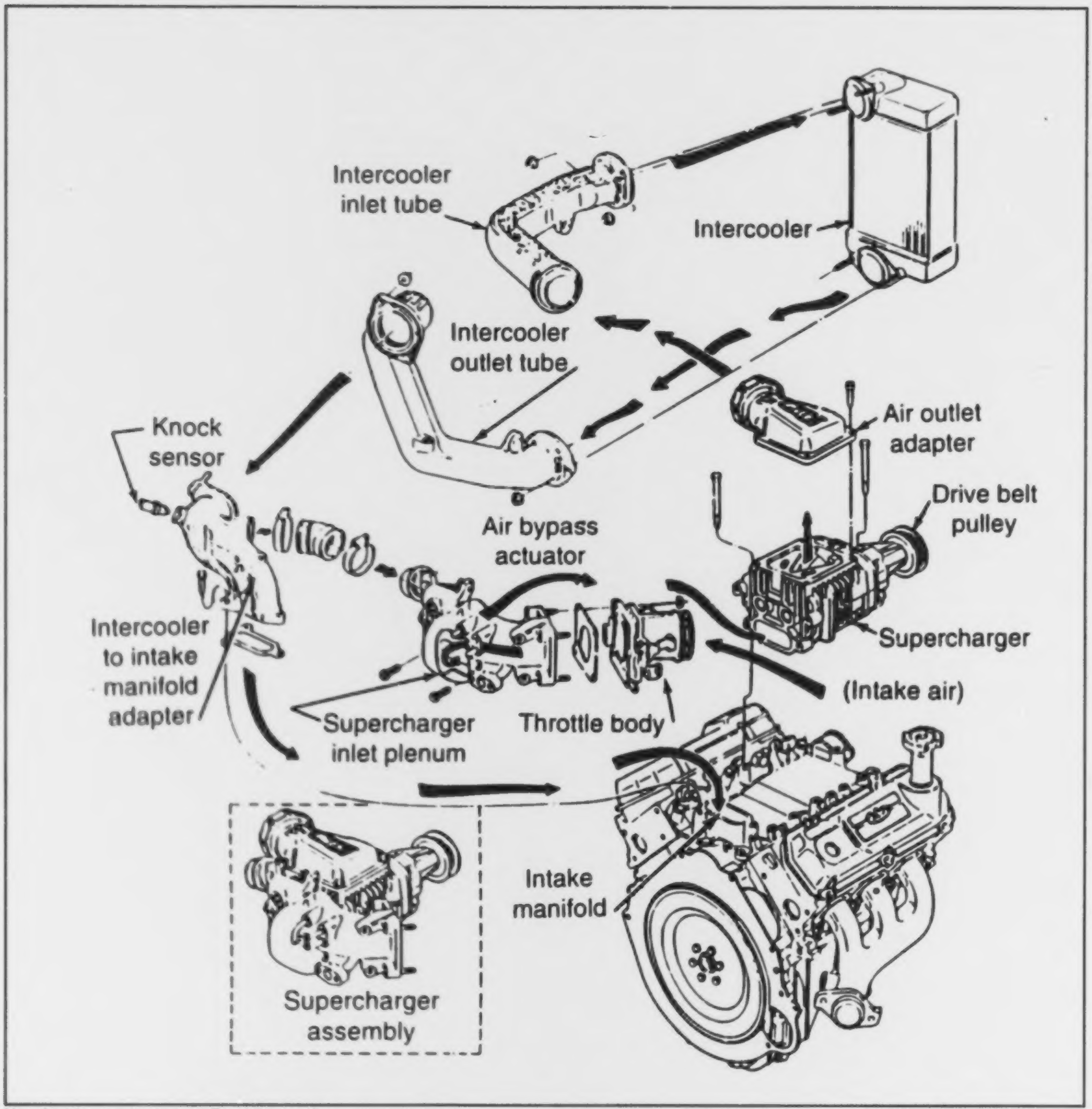
OBJECTIVE 7 **Complete Assignment Sheet 1.**

OBJECTIVE 8 **Label the parts of a supercharger indicated on an illustration.**

Required Activities/
Resources
– Supercharger

☞ Examine the parts of a supercharger that are displayed.

FIGURE 2


Intercooler inlet tube
Intercooler
Intercooler outlet tube
Knock sensor
Air outlet adapter
Drive belt pulley
Air bypass actuator
Intercooler to intake manifold adapter
Supercharger
(Intake air)
Supercharger inlet plenum
Throttle body
Intake manifold
Supercharger assembly

Used with permission of Ford Motor Co.

☑ **NOTE:** The supercharger assembly is part of an integrated engine system and is not a bolt-on option.

OBJECTIVE 9

Required Activities/
Resources
– Transparency Master 2

Optional Activities/
Resources in
Instructor's Guide

Match the names of the parts of a supercharger to descriptions of their functions.

Look at transparency 2 as your instructor describes the functions of the parts of a supercharger.

WORDS YOU SHOULD KNOW	
boost	increase in engine power which results from turbocharger or supercharger operation
detonation	a rapid explosion of the air-fuel mixture in the engine's cylinders which vibrates the combustion chamber walls

- **drive belt pulley** — transfers energy from the engine crankshaft to operate the supercharger
- **throttle body** — mixes and measures the amount of air that goes into the supercharger

  ☑ **NOTE:** The closing of the valve gives the supercharger more boost by directing more air to the intake manifold in direct response to accelerator pedal pressure.

- **supercharger inlet plenum** — allows outside air to enter the supercharger
- **air bypass actuator** — directs excess air in the intake manifold back to the supercharger inlet plenum

  ☑ **NOTE:** When supercharger power is not needed, this air bypass allows the supercharger to idle.

- **supercharger** — compresses air for combustion in engine cylinders in direct relationship to engine crankshaft speed

  ☑ **NOTE:** When air is compressed, it becomes superheated and must be cooled down or the air- fuel mixture will explode prematurely — a condition called *detonation.*

- **air outlet adapter** — directs the hot compressed air from the supercharger to the intercooler inlet tube

- **intercooler inlet tube** — directs the hot compressed air into the intercooler

- **intercooler** — reduces the temperature of the hot compressed air coming from the supercharger

  ☑ **NOTE:** When air is compressed, its temperature goes up. This air must be cooled before it goes to the cylinder or it will ignite prematurely. The intercooler, sometimes called a *charge air cooler*, can decrease the temperature of the air by as much as 150 degrees Fahrenheit. Because cooler air carries more oxygen, this cooling causes a further increase in power output created by the supercharger.

- **intercooler outlet tube** — directs cooled compressed air leaving the intercooler

- **knock sensor** — signals the engine computer to retard the ignition spark if detonation begins

- **intercooler to intake manifold adapter** — directs cooled compressed air leaving the intercooler to the intake manifold

- **intake manifold** — tubes through which the air-fuel mixture flows from the throttle valve to the intake ports in the cylinder head

OBJECTIVE 10 **Compare and contrast a turbocharger and a supercharger.**

Required Activities/
Resources
– Explanation

Listen as your instructor explains about the similarities and differences between the operation of a turbocharger and a supercharger.

	Turbocharger	**Supercharger**
Function	Compresses air to boost engine power	Compresses air to boost engine power
Performance	35%-60% increase Lag between acceleration & turbo boost	35%-60% increase Instant response to acceleration
Operation	Exhaust-driven	Belt-driven
Lubrication System	Linked to engine	Self-contained
Normal Unit Noise	Pressure pulsation & gear noise	High frequency whine

OBJECTIVE 11 **Complete Job Sheet 3.**

OBJECTIVE 12 **Complete Job Sheet 4.**

OBJECTIVE 13 **Complete Assignment Sheet 2.**

ASSIGNMENT SHEET 1

SERVICING TURBOCHARGER SYSTEMS

10

Name ______________________________ Score __________

OBJECTIVE 7

Identify the causes of turbocharger failure.

INTRODUCTION

When properly maintained, a turbocharger's service life should range from 50,000 to over 100,000 miles. Most turbocharger failures are caused by lack of lubrication, contaminated oil, or foreign object damage to the compressor blades.

If turbocharger system problems arise, many are signaled by turbocharger noise or leaking shaft seals. The turbocharger has its own distinctive sound or noise level. Often problems can be identified by listening for either an unusually high or an unusually low pitched sound. Excessive oil consumption could be an indication of leaking turbocharger shaft seals, since the seals are designed to prevent the oil from leaking into the compressor and turbine housings before returning to the engine through the oil drain line. Usually a damaged turbocharger is not serviceable and must be replaced as a unit.

EQUIPMENT AND SUPPLIES

- Handout 1, Turbocharger Diagnosis Chart

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

Cognitive Activities
- Draw conclusions
- Transfer knowledge/training to new situations

Use the introduction to this Assignment Sheet and Handout 1, Turbocharger Diagnosis Chart, to help you with this Assignment Sheet. Read each of the following questions carefully, then select the answer for each that is correct. Write the correct letter in the blank.

_____ 1. The owner of a vehicle complains of blue exhaust smoke. Which of the following is a possible cause?

A. Turbocharger oil supply is restricted.
B. Turbocharger air inlet is restricted.
C. Turbocharger oil drain hose is restricted.
D. Throttle body air inlet is restricted.

Job Acquisition/ Development
- Master specific job task/procedure

____ 2. How would you repair a turbocharged engine with a leak at the turbocharger oil inlet?

A. Repair vacuum leaks in engine.
B. Adjust the boost pressure in actuator.
C. Repair the turbocharger oil inlet fittings.
D. Replace the turbocharger.

____ 3. What could be an indication that a turbocharger has an air inlet restriction?

A. The engine surges.
B. The engine detonates.
C. The engine has low power.
D. The engine is using oil excessively.

____ 4. You have just determined that a turbocharger has leaking seals. How would you solve the problem?

A. Replace the turbocharger.
B. Repair the throttle body.
C. Repair the vacuum leaks.
D. Check the turbocharger oil delivery system.

____ 5. Which of the following would cause a turbocharged engine to experience low engine power?

A. Too much boost allowed by the turbocharger actuator.
B. A leak in the turbocharger oil drain hose.
C. A restriction in the turbocharger oil supply.
D. A restriction in the turbocharger air inlet.

____ 6: Which of the following is a reason to replace the turbocharger?

A. The turbocharger actuator allows too much boost.
B. The turbocharger actuator allows too little boost.
C. The turbocharger has an internal defect.
D. The turbocharger oil drain line is defective.

____ 7. In following up on a customer complaint, you find that the turbocharger bolts are loose on the compressor side. Which of the following conditions could result from this?

A. Engine surges
B. Engine noise
C. Engine detonation
D. Low engine power

____ 8. Which of the following could cause a noise in a turbocharged engine?

A. A defect in the throttle body power system
B. A loose or leaking exhaust system
C. A malfunction in the spark advance or retard system
D. A leak in the engine vacuum

____ 9. You have just determined the possible cause of a detonating engine as too much boost allowed by the actuator. What action would you take to correct the problem?

A. Check the oil delivery system.
B. Check the boost pressure and adjust.
C. Remove the inlet restrictions.
D. Replace the turbocharger.

Name ______________________________ Score __________

OBJECTIVE 13 **Identify the causes of supercharger failure.**

INTRODUCTION

A supercharger requires little maintenance due to the fact that the oil system is self-contained. Although no oil change is required, supercharger problems will occur if oil is not added at regular intervals to maintain an adequate supply. Other supercharger problems may include vacuum and pressure leaks. Vacuum leaks can allow dirt and moisture into the engine causing it to idle roughly and run lean. Pressure leaks can be detected by a whistling sound and low boost pressure. Usually a damaged supercharger is not serviceable and must be replaced as a unit.

EQUIPMENT AND SUPPLIES

- Handout 2, Supercharger Diagnosis Chart

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

Cognitive Activities
- Draw conclusions
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure

Use the introduction to this Assignment Sheet and Handout 2, Supercharger Diagnosis Chart, to help you with this Assignment Sheet. Read each of the following questions carefully, then select the answer for each that is correct. Write the correct letter in the blank.

_____ 1. Following up on a customer complaint, you find that the supercharger is not turning. Which of the following would you do next?

A. Check the condition and tension in the supercharger drive belt.
B. Check the function of the bypass actuator.
C. Check for damage or restrictions in the exhaust system.
D. Replace the supercharger.

____ 2. You examine a vehicle with oil on the outside of the supercharger. Which of the following is a possible cause?

A. Supercharger not turning
B. Leaking joint seals
C. Too much oil flow
D. Bypass not closing

____ 3. You have just determined that a vehicle has excessively leaking oil seals. Which of the following would be the proper corrective measure?

A. Replace the supercharger.
B. Service the supercharger.
C. Tighten the oil seals.
D. Replace the oil seals.

____ 4. A customer brings in a supercharged vehicle complaining that the vehicle response is "too touchy" and has poor fuel economy. Which of the following supercharger problems could cause this?

A. The bypass actuator not closing
B. The bypass actuator not opening
C. Air leaks at the intercooler
D. A loose oil fill plug

____ 5. You have just determined that the reason a customer's vehicle is getting low boost pressure is that the bypass valve actuator is not closing. Which of the following actions should you take?

A. Check drive belt tension and condition.
B. Replace the supercharger.
C. Check that the bypass actuator is operating.
D. Check for the correct pulley diameter.

____ 6. What action should you take if you are checking a noisy supercharger and find there is no oil in the supercharger?

A. Check the stop adjustments of the actuator.
B. Check for a kink in the vacuum tube.
C. Replace the supercharger.
D. Replace the oil.

_____ 7. In following up on a customer complaint, you find insufficient air flow from the supercharger. What could cause this problem?

A. Stuck actuator
B. A defective wastegate
C. Too much air flow
D. A loose oil fill plug

_____ 8. A noisy supercharger is determined to have a damaged rotor. Which of the following is the solution to this problem?

A. Replace the intercooler.
B. Replace the supercharger.
C. Repair the bypass valve.
D. Repair the actuator diaphragm.

_____ 9. You have just determined that a supercharger has a boost that is too high. How would you begin to find the problem?

A. Check the function of the bypass actuator.
B. Check for a stuck or restricted bypass valve.
C. Check for low boost.
D. Check for exhaust restrictions or damage.

_____ 10. You have explained to a customer that seal damage is a possible cause for replacing a supercharger. Which of the following is another possible cause?

A. Rotor damage
B. Air leak at the supercharger outlet
C. Loose oil fill plug
D. Bypass actuator not opening

JOB SHEET 1

SERVICING TURBOCHARGER SYSTEMS

10

Name ____

OBJECTIVE 5

Test the operation of a turbocharger system.

Required Activities/Resources
- Explanation

Listen to your instructor's explanation of the things you should look and listen for when testing the operation of a turbocharger.

INTRODUCTION

A turbocharged engine must have an adequate supply of clean, unrestricted oil to continue working properly. Restricted oil flow or contamination of the oil are frequent causes of turbocharger failure. The engine oil and filter should be changed regularly. Many manufacturers recommend an oil change on turbocharged engines twice as often as for systems without a turbocharger.

Part of testing turbocharger systems involves listening for changes in turbocharger sound cycles or intensity and visually inspecting all hoses, gaskets, and tubing for proper fit, damage, and wear. An air leak between the compressor outlet and the engine or an exhaust leak between the engine and the turbocharger are identifiable by a high-pitched sound when the engine is running. As you become more familiar with the normal sound of a properly running turbocharger, it will be easier to notice if the sound cycles or changes in intensity. A turbocharger gets extremely hot and cools slowly. You should allow the turbocharger time to cool before performing any diagnosis or service work.

Since the correct procedure for testing the operation of a turbocharger varies with the manufacturer, consult the appropriate service manual to determine the appropriate method.

EQUIPMENT AND SUPPLIES

- Vehicle with a turbocharger
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 2

SERVICING TURBOCHARGER SYSTEMS

Name ______________________________

OBJECTIVE 6 **Remove, clean, inspect, repair, and replace turbocharger system components.**

INTRODUCTION

Turbochargers on today's vehicles are generally extremely complex, precision systems. In most cases, service to the turbocharger must be done by the manufacturer. Some manufacturers even warn that any effort to dismantle the turbocharger will void its warranty. As a result, the Engine Performance Technician will usually remove and install a replacement rather than actually repairing the turbocharger unit.

After the replacement turbocharger has been installed, certain lubrication precautions must be taken. Because the rotating parts of the turbocharger operate at such a high speed while the engine is running, it is necessary that the turbocharger bearings have oil before the engine is started and that adequate turbocharger lubrication is maintained at all times. These precautions will prevent premature turbocharger failure.

Since the correct procedure for removing or installing a turbocharger varies, always consult the appropriate service manual. The following guidelines should be helpful.

Guidelines:

- Before servicing a turbocharger, clean the turbocharger area or rotating assembly with an approved cleaning solvent and a soft wire brush. Using hard metal objects or sandpaper to remove carbon deposits can damage the metal, causing vibration or other serious damage to the turbocharger.
- Change the engine oil and filter to ensure the replacement turbocharger has clean and adequate lubrication.
- Use a top quality lubricant that meets or exceeds the manufacturer's recommendations.

- Prime the turbocharger prior to engine operation to prevent a dry start.

  ☞ **NOTE:** To prime the turbocharger, disconnect the coil secondary wire at the distributor cap and ground the coil wire. Then, crank the engine over until a steady oil pressure is observed. Finally, reconnect the coil wire. This will prevent the turbocharger from damage by supplying oil to the turbocharger bearings before the vehicle is started.

- Allow the engine and engine oil to warm by running the turbocharged engine at a slow idle for a few minutes before driving.
- Idle the turbocharged engine down for a few minutes after driving to allow the engine to cool before shutting it off.

EQUIPMENT AND SUPPLIES

- Vehicle equipped with a turbocharger
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 3 — SERVICING TURBOCHARGER SYSTEMS

Name ____

OBJECTIVE 11

Test the operation of a supercharger system.

Required Activities/Resources
- Explanation

Listen as your instructor explains what you should look and listen for when you are testing the operation of a supercharger.

INTRODUCTION

A supercharged system may experience problems such as vacuum or pressure leaks. If the problem is a vacuum leak, the engine may idle roughly or stall. This will occur when more air enters the engine than is sensed by the throttle body or air-flow meter. Pressure leaks often can be detected by a whistling sound while the supercharged engine is running with boost.

The correct procedure for testing the operation of a supercharger varies with the manufacturer. Consult the appropriate service manual.

EQUIPMENT AND SUPPLIES

- Vehicle equipped with a supercharger
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 4

SERVICING TURBOCHARGER SYSTEMS

10

Name ____

OBJECTIVE 12

Remove, clean, inspect, repair, and replace supercharger system components.

INTRODUCTION

Service to a supercharger needing repair must be done by the manufacturer. A defective supercharger is serviced only as an assembly; the defective unit is replaced with a new or rebuilt one. As a result, the Engine Performance Technician will remove a defective supercharger and install a replacement rather than actually repair the supercharger unit.

After installation, the supercharger requires little maintenance, largely because the supercharger's oil supply is self-contained. The needle roller bearings supporting the timing gears on the internal rear rotors are greased for life. However, the ball bearings supporting the timing gears on the internal front rotors are lubricated by gear oil. A plug allows for periodic checks of the oil level at the ball bearings. This specified interval varies with the manufacturer.

The correct procedure for removing or installing superchargers varies. Consult the manufacturer's service manual. The following maintenance guidelines should be helpful.

Guidelines:

- Check for low oil at the front rotor ball bearings, and add as recommended in the vehicle maintenance schedule.

  ☑ **NOTE:** Supercharged engines use a synthetic based oil that is specifically formulated for high speed use.

- Inspect the drive belt for cracks, looseness, and wear.
- Change the filter in the air cleaner as required by the manufacturer.
- Clean any dirt and debris out of the intake system with an approved cleaning solvent and a soft wire brush.
- Check all clamps and connections for tightness.

EQUIPMENT AND SUPPLIES

- Vehicle equipped with a supercharger
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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EVALUATOR'S COMMENTS

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____

____

OBJECTIVE SHEET

SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

11

INTRODUCTION

During the normal operation of an internal combustion engine, fuel and water vapors collect in the crankcase. These vapors are known as *blow-by*. If allowed to remain in the crankcase, the blow-by will react with oil to form sludge. If this sludge is circulated, it can corrode and wear out the internal components of the engine. The PCV system draws fresh air through the crankcase, picks up blow-by, and redirects the unburned fuel back into the intake manifold for combustion. The PCV system was one of the first emission control devices added to vehicles to help solve the problem of air pollution. Before the PCV, blow-by gases were vented directly into the atmosphere.

PREREQUISITE

Unit 10, "Servicing Turbocharger Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS

PREREADING:	Read Paul Stenquist's article, "When Your Car Uses Too Much Oil," from *Popular Mechanics* magazine, December 1990, p. 99. As you read, consider how a failure in the positive crankcase ventilation system can cause your car to use too much oil.
WRITING:	Write a short (one paragraph to one page) explanation of how you can test the positive crankcase ventilation system to determine if it is working correctly.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. State the purpose of a positive crankcase ventilation system.
2. Describe the operation of a positive crankcase ventilation system.
3. List the locations on a vehicle where a positive crankcase ventilation system may be installed.
4. Test the operation of a positive crankcase ventilation system. (Job Sheet 1)
5. Inspect, service, and replace positive crankcase ventilation system parts. (Job Sheet 2)

INFORMATION SHEET

SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

11

OBJECTIVE 1

State the purpose of a positive crankcase ventilation system.

The positive crankcase ventilation (PCV) system reduces vehicle emissions and protects engine parts from sludge by removing blow-by from the crankcase.

OBJECTIVE 2

Required Activities/ Resources
- Explanation

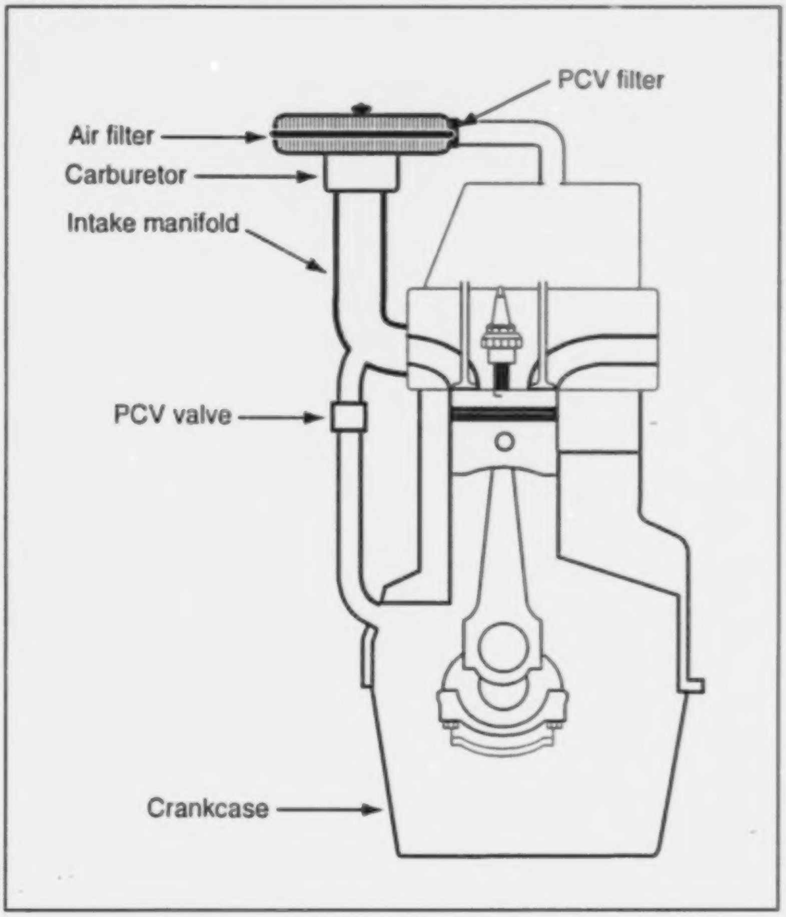
Describe the operation of a positive crankcase ventilation system.

Look at Figure 1 as your instructor explains how a positive crankcase ventilation system operates.

The positive crankcase ventilation (PCV) system works by allowing fresh air to be supplied to the crankcase where it is mixed with blow-by gases, directed through a PCV valve or vapor separator, and sent into the intake manifold. From the intake manifold, the gases go to the combustion chamber where they are burned. (Figure 1)

EXAMPLE:

FIGURE 1


PCV filter
Air filter
Carburetor
Intake manifold
PCV valve
Crankcase

OBJECTIVE 3
Required Activities/
Resources
- Vehicles with a PCV system

List the locations on a vehicle where a positive crankcase ventilation system may be installed.

☞ Watch as your instructor shows you where the PCV system is located on different vehicles.

- Located between the valve cover and the intake manifold
- Located between the engine block and the intake manifold

OBJECTIVE 4

Complete Job Sheet 1.

OBJECTIVE 5

Complete Job Sheet 2.

JOB SHEET 1

SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS

Name ______________________________

OBJECTIVE 4 **Test the operation of a positive crankcase ventilation system.**

INTRODUCTION

The PCV system should be routinely checked during a regular engine tune-up. Unexplained oil leaks can sometimes be traced to a malfunctioning PCV valve which lets pressure build up in the crankcase. Other signs of a defective PCV system are an oily air filter, oil leaking from any engine seal, or excessive blow-by. The PCV system should be checked if any of these symptoms are present. The system should be checked routinely and the PCV valve replaced every 15,000 miles.

EQUIPMENT AND SUPPLIES

- Vehicle
- Appropriate service manual

PROCEDURE

Yes No

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

1. Put the vehicle in neutral. ____ ____

⚠ **DANGER:** UNVENTED EXHAUST FUMES in a closed building can cause death. ALWAYS CONNECT THE VEHICLE'S EXHAUST TO A VENT HOSE WHEN YOU RUN AN ENGINE IN A CLOSED SHOP.

2. Raise the hood. ____ ____
3. Start the engine and let the engine idle until the temperature gauge moves into the normal range. ____ ____
4. With the engine running, remove the hose between the air filter housing and the valve cover at the air filter connection. ____ ____

Research and Reference
- Use standard references

Functional Reading
- Use content area vocabulary
- Interpret abbreviations/acronyms

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

⚠ **CAUTION:** ENGINES THAT HAVE BEEN RUNNING are hot. USE CAUTION WHEN WORKING AROUND ENGINES THAT HAVE BEEN RUNNING.

⚠ **WARNING:** LOOSE CLOTHING, HAIR, OR JEWELRY can be caught in moving parts while the engine is running. KEEP CLEAR OF MOVING PARTS.

---

5. Wait a few seconds and put your hand over the end of the hose. ____ ____

   ☑ **NOTE:** If you do not feel a vacuum, either (1) the hose is clogged, (2) there is an air leak in the system, or (3) the PCV valve is defective.

6. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructors. ____ ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1

Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 2 — SERVICING POSITIVE CRANKCASE VENTILATION SYSTEMS — 11

Name ______________________________

OBJECTIVE 5

Inspect, service, and replace positive crankcase ventilation system parts.

INTRODUCTION

The positive crankcase system (PCV) is not adjustable. Service consists of the replacement of worn parts. The location of the PCV valve on the engine varies from vehicle to vehicle. It is generally found between the engine valve cover and a vacuum source at the intake manifold below the carburetor. Refer to the manufacturer's service manual for its exact location. In many cases the PCV valve is installed in the engine valve cover by means of a rubber grommet. The grommet has a flexible opening. This allows the PCV valve to be installed or removed by snapping it in or out by hand.

EQUIPMENT AND SUPPLIES

- Vehicle with a PCV system which has a PCV valve
- Appropriate service manual
- New air filter, if needed
- PCV hoses, if needed
- PCV filter, if needed
- New PCV filter retainer clip, if needed
- Basic hand tool set

NOTICE: PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

Research and Reference
- Use standard references

Functional Reading
- Interpret graphics and symbols
- Use content area vocabulary
- Interpret abbreviations/acronyms

		Yes	No
1.	Make sure the hose between the air filter housing and the valve cover at the air filter connection is not clogged. If it is, remove the obstruction and/or replace the hose.	____	____
2.	Examine the connections of all PCV hoses to make sure they are tight and not allowing air to leak into the system.	____	____
3.	Examine all PCV hoses for kinks and cracks. If any are found, replace the hose(s).	____	____

Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

4. If it is necessary to replace a PCV hose, pull it from its connections and replace it only with a hose made for PCV and fuel system service. ____ ____

☞ **NOTE:** Regular water hose will not stand up to blow-by vapors.

5. Remove the air cleaner cover and check the air filter. ____ ____

6. If it is dirty, replace it. ____ ____

7. Check the PCV filter. ____ ____

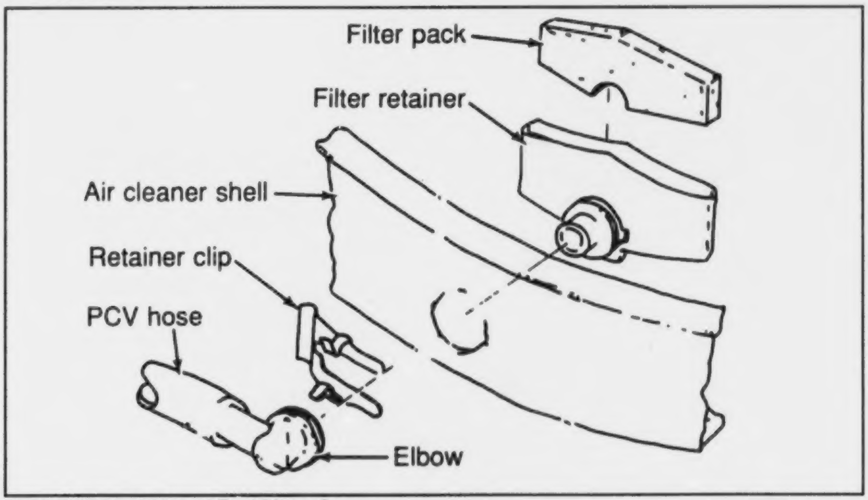
☞ **NOTE:** If it is oily, the PCV system may not be working properly.

8. If it is necessary to replace the PCV filter, slide the retainer clip aside and remove the PCV filter from the air cleaner housing. ____ ____

☞ **NOTE:** The PCV filter cannot be cleaned.

9. Insert a new PCV filter, using a new retainer clip if necessary. (Figure 1) ____ ____

FIGURE 1



Used with permission of Ford Motor Co.

Yes No

10. Replace the air cleaner cover. ____ ____

11. Start the engine. ____ ____

12. Remove the PCV valve from the valve cover and listen for a hissing sound. ____ ____

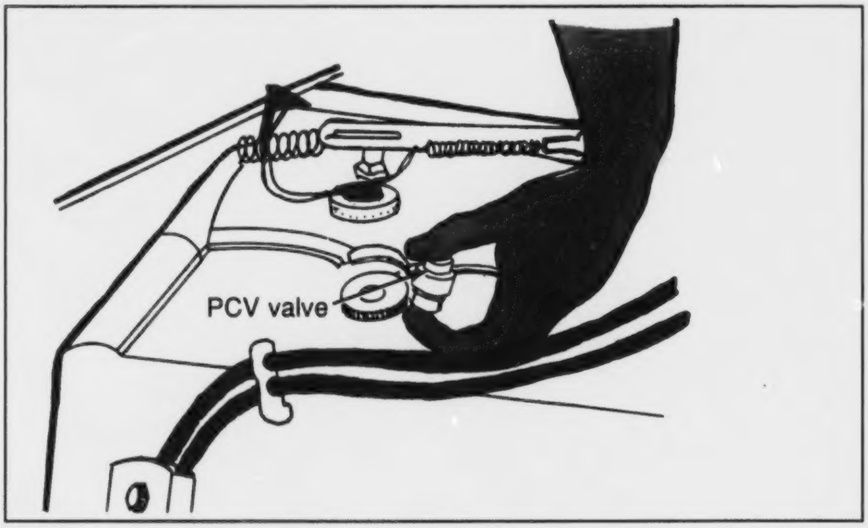
☑ **NOTE:** If the PCV system is not clogged, hissing can be heard as air passes through the valve.

13. Place your finger at the end of the valve to check for vacuum. ____ ____

14. If there is little or no vacuum, check for a plugged or restricted hose. (Figure 2) ____ ____

☑ **NOTE:** The vacuum can be tested with a vacuum gauge.

FIGURE 2

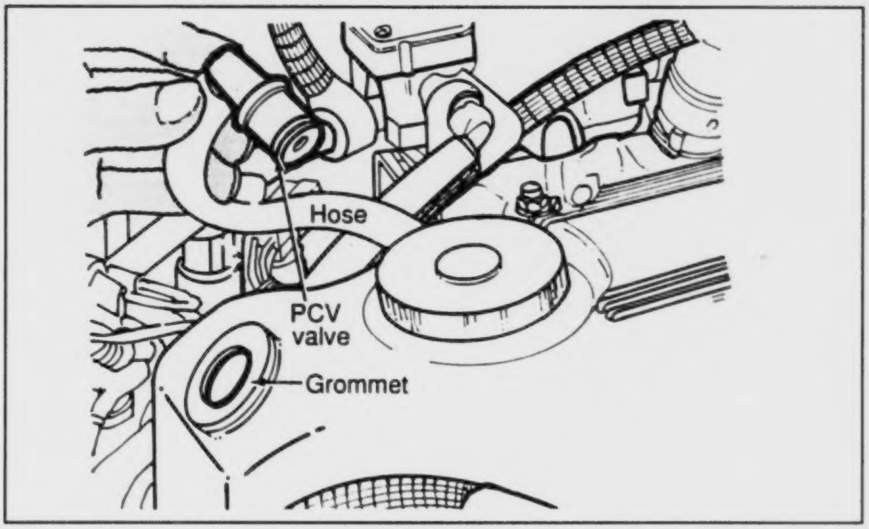


15. If the PCV valve or hose is clogged, replace the affected part. (Figure 3) ____ ____

IMPORTANT: The PCV valve has to control the recirculation of exhaust gases to within specific guidelines. It is extremely important to use only the PCV valve designed for your engine. It should be replaced every 15,000 miles.

Yes No

FIGURE 3



16. Turn off the engine. ____ ____

17. Reinstall or replace the PCV valve. ____ ____

18. Reconnect the hose between the air filter housing and the valve cover. ____ ____

19. Clean your work area and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. ____ ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3.	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

OBJECTIVE SHEET

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

12

INTRODUCTION

Automobile emissions can be a significant source of air pollution. Over the years, improvements to the engine and the ignition and fuel systems have reduced these pollutants. One type of air pollution is smog which is caused by the reaction of nitrogen oxides and hydrocarbons to sunlight. A vehicle's exhaust gas recirculation (EGR) system is the main, and sometimes only, emission control system that reduces smog by lowering the amount of nitrogen oxide (NO_x) in automobile exhaust. EGR systems have been included as standard emission control equipment on vehicles since 1974. Because there are many different types of EGR systems, from simple to very sophisticated, it is a challenge for the Engine Performance Technician to understand, diagnose, and correct any problems associated with them.

PREREQUISITE

Unit 11, "Servicing Positive Crankcase Ventilation Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS

PREREADING:	Read the article "EGR and Exhaust Simulation Developments" in *Automotive Engineering*, August 1993, pp. 14-15, which describes a new application of exhaust gas recirculation systems.
WRITING:	Write one or two paragraphs on the new Combustion Control by Vortex Stratification (CCVS) developed in 1992. Explain how it works and how it benefits our environment.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. State the function of an exhaust gas recirculation (EGR) system.
2. Describe the operation of an exhaust gas recirculation system.
3. Identify whether an exhaust gas recirculation system is on or off during specified engine operating conditions.
4. Match the names of types of exhaust gas recirculation systems to descriptions of their operation.
5. Test the operation of an exhaust gas recirculation system. (Job Sheet 1)
6. Inspect, test, repair, and replace electrical/electronic controls and wiring. (Job Sheet 2)
7. Inspect, test, repair, and replace vacuum/pressure controls, filters, and hoses. (Job Sheet 3)
8. Inspect, test, repair, and replace the valve and exhaust passages. (Job Sheet 4)

INFORMATION SHEET

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

12

OBJECTIVE 1

State the function of an exhaust gas recirculation (EGR) system.

Required Activities/
Resources
– Explanation

Listen as your instructor explains the role vehicle emissions play in air pollution.

WORDS YOU SHOULD KNOW

nitrogen oxide (NO_x)	the combination of nitrogen and oxygen molecules which is part of automotive exhaust emissions and a basic air pollutant. When combined with hydrocarbons in the atmosphere, NO_x creates smog

The exhaust gas recirculation (EGR) system reduces the amount of nitrogen oxide (NO_x) a vehicle emits into the air.

OBJECTIVE 2

Describe the operation of an exhaust gas recirculation system.

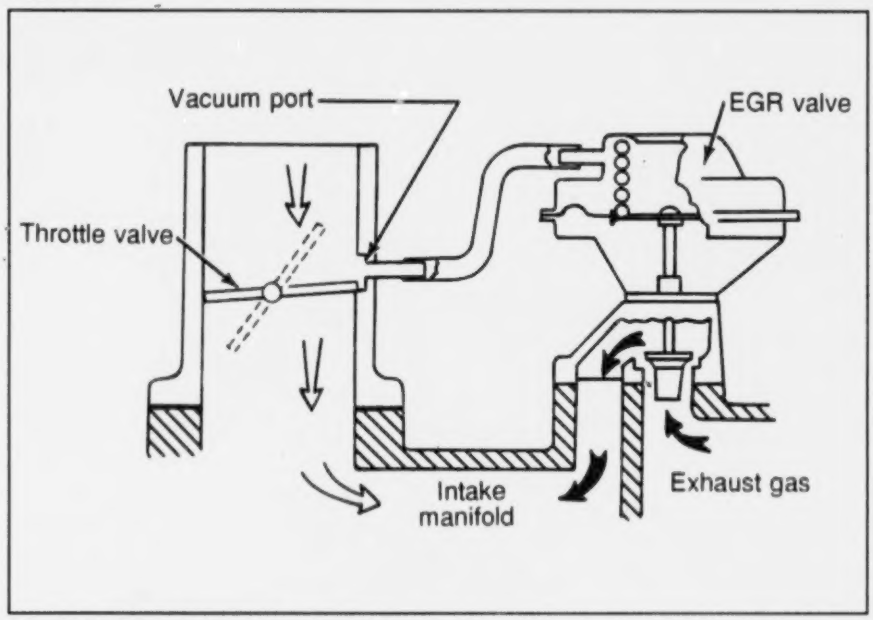
WORDS YOU SHOULD KNOW

exhaust	gases produced by the combustion in the cylinders which flow into the exhaust manifold and eventually into the atmosphere through the exhaust system
intake manifold	the part of the engine which holds the air or air-fuel mixture just before it flows into the cylinders for combustion

An EGR system allows a small amount of exhaust gas to return through the intake manifold into the cylinders where, by reducing the combustion temperature, it lowers the amount of NO_x formed.

EXAMPLE:

FIGURE 1



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NOTE: The EGR system usually operates by vacuum, opening and closing a special passageway between the engine's exhaust manifold and the intake manifold. The opening and closing of this passageway is controlled by either the EGR system or the engine computer in response to the engine's operating condition. (Figure 1)

OBJECTIVE 3

Required Activities/
Resources
– Explanation

Identify whether an exhaust gas recirculation system is on or off during specified engine operating conditions.

Listen as your instructor explains the relationship between engine operating conditions and EGR operation.

Engine Operating Condition	EGR Operation
Cruise	on
Acceleration	off
Idle	off
Cold Engine	off
Deceleration	on

☑ **NOTE:** In cruise and deceleration the EGR system is normally on; however, if the engine senses a load, the EGR may turn off. The EGR can also go off during acceleration if the engine senses a load, causing driveability problems such as surging, stalling, or detonation. Many vehicles have been equipped with computer-operated EGR valves that pulse to better control exhaust gas flow and improve driveability.

OBJECTIVE 4

Required Activities/
Resources
- EGR Valves
- Explanation

Match the names of types of exhaust gas recirculation systems to descriptions of their operation.

Examine the different types of EGR valves as they are passed around the room.

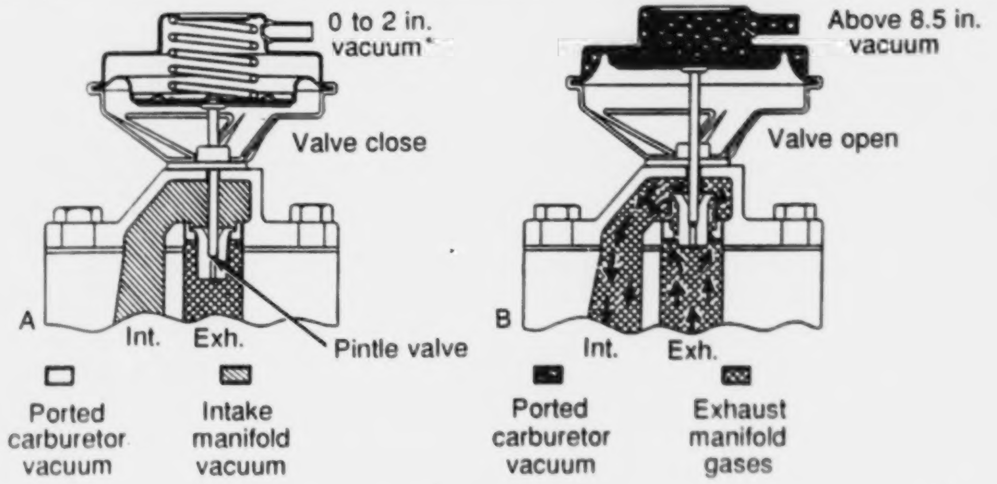
Listen as your instructor tells you some of the many different names vehicle manufacturers have for EGR valves and EGR systems.

WORDS YOU SHOULD KNOW	
backpressure	the pressure exerted by exhaust gases coming from the combustion chamber
solenoid	an electronic switch which either conducts or interrupts the flow of electric current flowing to a device operated by electricity

- **simple EGR system** — opens whenever engine conditions apply vacuum to the passage between the exhaust manifold and the intake manifold, allowing exhaust gases to flow into the intake manifold (Figure 2)

EXAMPLE:

FIGURE 2


0 to 2 in. vacuum*
Valve close
A
Int.
Exh.
Pintle valve
Ported carburetor vacuum
Intake manifold vacuum
Above 8.5 in. vacuum
Valve open
B
Int.
Exh.
Ported carburetor vacuum
Exhaust manifold gases

Exhaust gas recirculation valve action.

A. Low vacuum signal, valve is closed. B. High vacuum signal, diaphragm opens valve.

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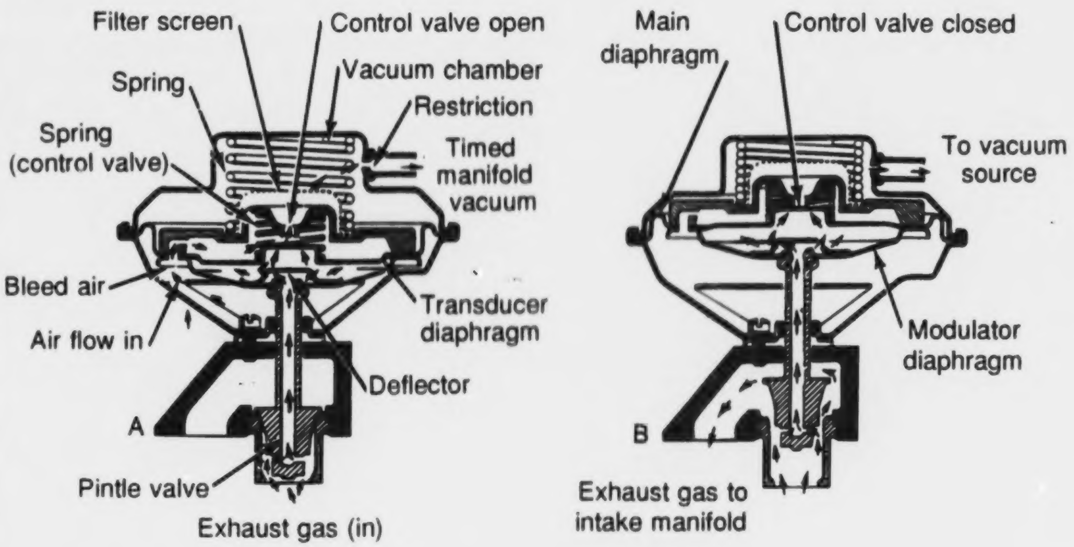
- **backpressure control EGR system** — regulates the flow of exhaust gas into the intake manifold based on the amount of exhaust gas backpressure in the exhaust manifold (Figure 3)

EXAMPLE:

FIGURE 3


Filter screen
Control valve open
Vacuum chamber
Spring
Restriction
Spring (control valve)
Timed manifold vacuum
Bleed air
Transducer diaphragm
Air flow in
Deflector
A
Pintle valve
Exhaust gas (in)
Main diaphragm
Control valve closed
To vacuum source
Modulator diaphragm
B
Exhaust gas to intake manifold

Internally modulated EGR valve.

A. Control valve is open, EGR valve is closed.

B. Exhaust backpressure closes control valve, causing EGR valve to open.

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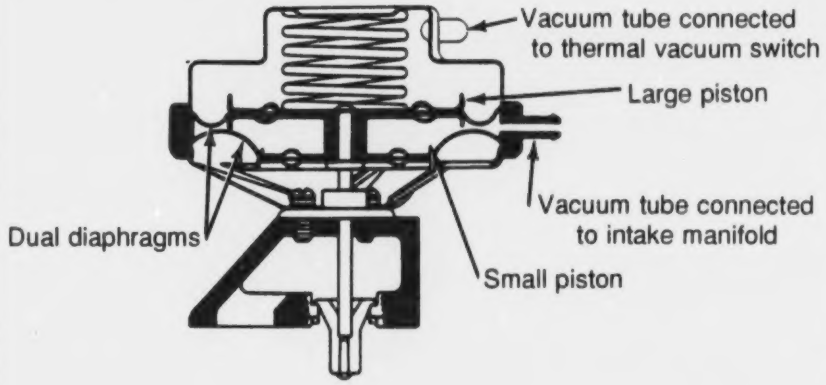
☑ **NOTE:** There are two types of backpressure control valves, *positive* and *negative*. The *positive backpressure valve* uses positive or increasing exhaust backpressure to increase exhaust gas flow. The *negative backpressure valve* reacts to decreasing backpressure and is used more often in high performance cars.

- **thermal vacuum EGR system** — senses engine temperature and prevents exhaust gas flow until the engine temperature reaches manufacturer's specifications (Figure 4)

EXAMPLE:

FIGURE 4


Vacuum tube connected to thermal vacuum switch
Large piston
Vacuum tube connected to intake manifold
Dual diaphragms
Small piston

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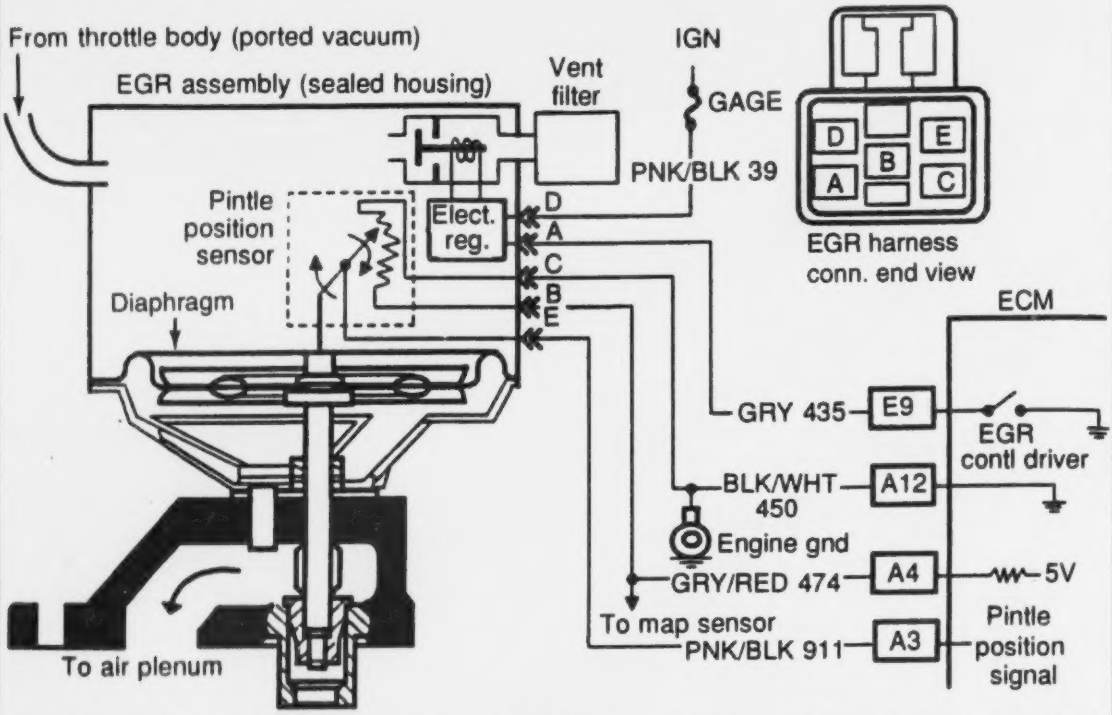
- **valve sensor EGR system** — Sensor monitors combustion temperature and relays this information to the engine computer which opens or closes the EGR valve to maintain an effective level of exhaust flow into the intake manifold.

- **built-in electronic EGR system** — uses voltage signals from the engine computer through solenoids to electronically regulate vacuum pressure and exhaust gas flow (Figure 5)

EXAMPLE:

FIGURE 5


From throttle body (ported vacuum)
EGR assembly (sealed housing)
Vent filter
IGN
GAGE
PNK/BLK 39
D
E
B
A
C
EGR harness conn. end view
Pintle position sensor
Elect. reg.
D
A
C
B
E
Diaphragm
ECM
GRY 435
E9
EGR contl driver
BLK/WHT 450
A12
Engine gnd
GRY/RED 474
A4
5V
To map sensor
PNK/BLK 911
A3
Pintle position signal
To air plenum

The integrated electronic EGR valve contains a built-in vacuum regulator, solenoid, and pintle position sensor.

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☑ **NOTE:** Vehicle manufacturers have different names for their EGR systems and components. Refer to each vehicle's service manual for specific EGR terms.

OBJECTIVE 5 **Complete Job Sheet 1.**

OBJECTIVE 6 **Complete Job Sheet 2.**

OBJECTIVE 7 **Complete Job Sheet 3.**

OBJECTIVE 8 **Complete Job Sheet 4.**

1000

JOB SHEET 1

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

12

Name ____

OBJECTIVE 5

Test the operation of an exhaust gas recirculation system.

Required Activities/
Resources
- Discussion
- Computer analyzer
- Scan tool
- Handout

Participate in a discussion reviewing the operation of computer analyzers and scanners.

Review the Handout, Exhaust Gas Recirculation System Diagnosis Chart.

INTRODUCTION

Improper operation of the EGR system can cause performance and driveability problems such as rough idle, surging, stalling, non-starting, detonation, and poor fuel economy. (Refer to the Handout.) However, because these same conditions can be caused by other problems in a vehicle, it is important that a complete diagnosis of the vehicle be done before focusing on the EGR system as the primary cause of the problems. A thorough inspection of the operation of the entire EGR system in this Job Sheet is necessary before focusing on more specific procedures covered in the following Job Sheets. On late model vehicles, accurate EGR testing is part of diagnosing the total system which is controlled by the central engine computer. On older vehicles, the EGR system can be tested separately.

Guidelines:

- As a part of testing, refer to the appropriate EGR diagnosis chart, and drive the vehicle for a road test, checking for load performance, rough idle, engine stalls, throttle detonations, or other conditions mentioned in the diagnosis chart.
- Perform a physical and visual inspection of the EGR system and components, looking for blocked passages, damaged delivery tubes, loose, sticky, binding or leaking valves, misrouted hoses, or loose bolts.
- Remove the EGR valve from the vehicle. (Valves are often found on or near the rear of the intake manifold.) Push up the valve stem and check for carbon on the pintle or seat, located at the base of the valve.

- Test the system with an engine computer analyzer or scan tool and vacuum pump.

EQUIPMENT AND SUPPLIES

- Vehicle with an EGR system (To best understand their variations, test several vehicles with different types of EGR systems.)
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to an appropriate service manual for make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret abbreviations/acronyms

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 2

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

Name ______________________________

OBJECTIVE 6

Inspect, test, repair, and replace electrical/electronic controls and wiring.

Required Activities/ Resources
- Vehicles with EGR systems

☞ Look at EGR wiring and electrical/electronic controls in several makes and models of vehicles.

INTRODUCTION

If the testing in Job Sheet 1 indicates a possible problem with the EGR system's electrical/electronic controls or wiring, further inspection is needed. Any vehicle's EGR system depends on properly functioning controls and wiring for best performance. In vehicles with computer controls, bad wiring can completely shut down the computer. A visual inspection should be made for frayed wiring or detached connections. The wiring is tested with a digital multimeter.

EQUIPMENT AND SUPPLIES

- Vehicle with an EGR system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to an appropriate service manual for make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

1004

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret abbreviations/ acronyms

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

____

____

____

JOB SHEET 3

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

12

Name ______________________________

OBJECTIVE 7

Inspect, test, repair, and replace vacuum/pressure controls, filters, and hoses.

Required Activities/ Resources
- Vehicles with EGR systems

☞ Look at the location of EGR vacuum/pressure controls, filters, and hoses in several makes and models of vehicles.

INTRODUCTION

If the testing in Job Sheet 1 indicates a possible problem with the EGR system's vacuum or pressure controls or filters and hoses, further inspection is needed. The hoses must have well-maintained filters and be properly connected for balanced EGR flow. You should visually inspect the controls, filters, and hoses for damage or looseness. On vehicles with a vacuum-operated EGR system, use a vacuum pump to check for output.

EQUIPMENT AND SUPPLIES

- Vehicle with an EGR system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to an appropriate service manual for make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret abbreviations/acronyms

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 4

SERVICING EXHAUST GAS RECIRCULATION SYSTEMS

Name ____________________

OBJECTIVE 8

Inspect, test, repair, and replace the valve and exhaust passages.

INTRODUCTION

If the testing in Job Sheet 1 indicates a possible problem with the EGR valve or exhaust passages, further inspection is needed. As EGR systems run, carbon deposits accumulate and clog passages in the exhaust manifold and, in extreme cases, cause EGR system failure. EGR valves can be stuck open or closed, causing different types of driveability problems. Valves stuck open cause stalling, cold starting, or surging. Valves stuck closed cause detonation, engine overheating, or rough idle. Depending on the type of valve in a vehicle's EGR, some can be cleaned and reused, while others must be replaced. Visually inspect the EGR valve and exhaust passages, checking for carbon deposits on valves that have been stuck open or closed. EGR valves are often found on or near the rear of the intake manifold, but the service manual will indicate their exact location and removal procedures.

EQUIPMENT AND SUPPLIES

- Vehicle with an EGR system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to an appropriate vehicle service manual for make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Interpret abbreviations/acronyms

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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OBJECTIVE SHEET

SERVICING AIR INJECTION SYSTEMS

13

INTRODUCTION

Current federal and state laws require emission controls on all vehicles. First introduced in the 1960s, air injection systems are one of the systems designed to reduce harmful exhaust emissions. Although the basic principles of air injection operation are the same, the parts of different air injection systems and the way they operate varies greatly from system to system. As an Engine Performance Technician, you will learn to repair and replace parts of these systems.

PREREQUISITE

Unit 12, "Servicing Exhaust Gas Recirculation Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS

PREREADING:	Read about an Environmental Protection Agency proposed emission test that uses a dynamometer to test vehicle emissions in the *Road and Track* article, "Tech Tidbits," by Dennis Simanaitis, July 1993, pp. 132-133.
WRITING:	Write a one page evaluation of the test based on the author's opinion and other information you might have regarding this test.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Job Sheets and by scoring at least 85% on the Written Test.

1010

SPECIFIC OBJECTIVES

1. State the function of an air injection system.
2. Label the components of a pump type air injection system indicated on an illustration.
3. Describe the operation of a pump type air injection system.
4. Match the names of the parts of a pump type air injection system to descriptions of their functions.
5. Describe the operation of a pulse air injection system.
6. Inspect and test components of an air injection system. (Job Sheet 1)
7. Remove, service, and replace the components of an air injection system. (Job Sheet 2)
8. Inspect, test, service, and replace pump unit components. (Job Sheet 3)
9. Inspect, test, and replace vacuum-operated air control valves and vacuum hoses. (Job Sheet 4)
10. Inspect and replace electrical/electronic-operated components and circuits. (Job Sheet 5)
11. Test the operation of an air injection system. (Job Sheet 6)

INFORMATION SHEET

SERVICING AIR INJECTION SYSTEMS

13

OBJECTIVE 1

State the function of an air injection system.

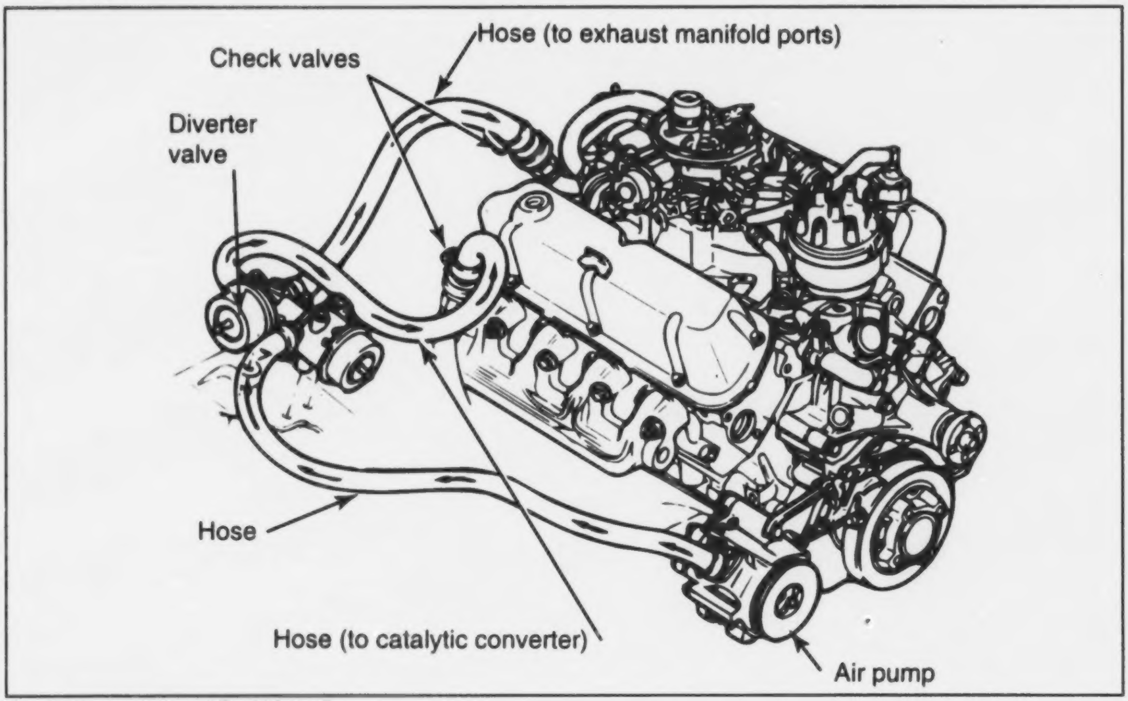
An air injection system reduces harmful exhaust emissions by forcing fresh air into the exhaust system.

☑ **NOTE:** The air injection system specifically reduces harmful hydrocarbons, carbon monoxide, and oxides of nitrogen (NO_x).

OBJECTIVE 2

Label the components of a pump type air injection system indicated on an illustration.

FIGURE 1


Hose (to exhaust manifold ports)
Check valves
Diverter valve
Hose
Hose (to catalytic converter)
Air pump

Used with permission of Ford Motor Co.

☑ **NOTE:** The illustration in Figure 1 shows only one of several types of pump type air injection systems.

OBJECTIVE 3

Required Activities/
Resources
– Transparency Master 1

Describe the operation of a pump type air injection system.

Look at transparency 1 as your instructor describes the operation of a pump type air injection system.

A pump type air injection system forces fresh air into either the exhaust manifold or the dual bed catalytic converter. Added to the exhaust manifold, the air causes the unburned fuel in the exhaust to burn in the hot exhaust manifold. Added to the catalytic converter, the additional air is used to mix with the harmful exhaust emissions to form harmless exhaust by-products such as water, carbon dioxide, and oxygen.

☑ **NOTE:** The engine computer monitors engine condition and activates the vacuum-operated air injection system. What information is monitored and how and when the various parts of the air injection system operate is determined by a great variety of factors. Different types of air injection systems can operate very differently.

OBJECTIVE 4

Required Activities/
Resources
– Parts of a pump type air injection system

Match the names of the parts of a pump type air injection system to descriptions of their functions.

Examine actual parts of an air injection system as your instructor describes the function of each.

- **air pump** — forces air at low pressure to the diverter valve
- **check valve** — prevents the hot exhaust gases from backing up in the system and entering and damaging the upstream components
- **diverter valve** — switches the flow of fresh air to either the exhaust manifold, the catalytic converter, or the atmosphere as needed.

OBJECTIVE 5

Required Activities/
Resources
– Explanation

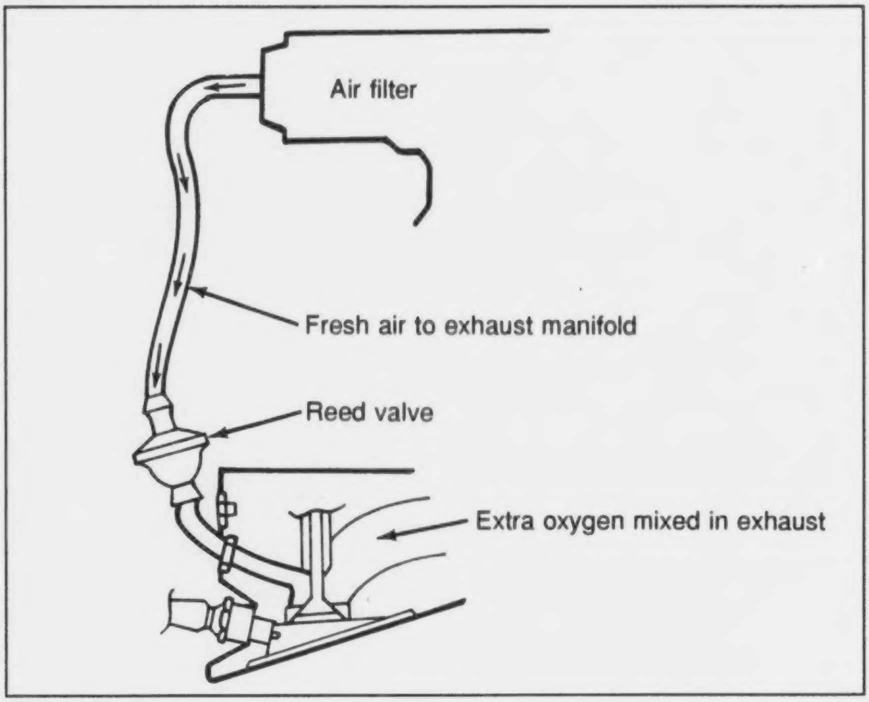
Describe the operation of a pulse air injection system.

Look at Figure 2 as your instructor explains how a pulse air injection system works.

In a pulse air injection system, a spring-loaded check valve, sometimes called a *reed valve* or an *aspirator valve*, is located in a hose connecting the air cleaner to the exhaust manifold and the catalytic converter. Negative pressure pulses from the normal operation of these exhaust components pull fresh air through the valve into the exhaust manifold and the catalytic converter. Positive pressure pulses cause the valve to close, keeping the hot exhaust gases from backing up inside the hose.

EXAMPLE:

FIGURE 2


Air filter
Fresh air to exhaust manifold
Reed valve
Extra oxygen mixed in exhaust

☑ **NOTE:** Several types of pulse air injection systems, sometimes called *aspirator air systems*, are in use. Some connect the air cleaner only to the catalytic converter rather than to both the catalytic converter and the exhaust manifold.

OBJECTIVE 6	**Complete Job Sheet 1.**
OBJECTIVE 7	**Complete Job Sheet 2.**
OBJECTIVE 8	**Complete Job Sheet 3.**
OBJECTIVE 9	**Complete Job Sheet 4.**
OBJECTIVE 10	**Complete Job Sheet 5.**
OBJECTIVE 11	**Complete Job Sheet 6.**

JOB SHEET 1 SERVICING AIR INJECTION SYSTEMS

Name ______________________________

OBJECTIVE 6 **Inspect and test components of an air injection system.**

Optional Activities/ Resources in Instructor's Guide

INTRODUCTION

Even though air injection systems normally have few parts, malfunctions can cause some problems. A problem in the air control valve could prevent the catalytic converter from functioning properly, causing increased emissions. A malfunction in the diverter valve could cause engine backfiring. A damaged check valve could allow hot gases to damage other air injection system parts.

Remember that the construction and functioning of air injection systems can vary widely. Be sure to consult the appropriate service manual for the correct testing procedures for the vehicle you are servicing. The following inspection guidelines should be helpful.

Guidelines:

- Inspect the air pump drive belt for wear, damage, and looseness.
- Inspect all air hoses for looseness, wear, and heat damage.

  ☑ **NOTE:** To find leaks, apply soapy water to the hoses and look for air bubbles.

- Inspect check valves for heat damage and signs of exhaust leaks.

EQUIPMENT AND SUPPLIES

- Vehicle with an air injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

Refer to the appropriate service manual for the make and model as equipped. Yes ____ No ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program;

additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

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JOB SHEET 2

SERVICING AIR INJECTION SYSTEMS

Name ______________________________

OBJECTIVE 7

Optional Activities/
Resources in
Instructor's Guide

Remove, service, and replace the components of an air injection system.

INTRODUCTION

Even though air injection systems are usually either pump type or pulse air type systems, the parts and operation of these can vary widely. Both types can service either the exhaust manifold, the catalytic converter, or both. The only way to know what parts are in the air injection system you are servicing is to refer to the appropriate service manual.

It is important to note that federal law prohibits tampering with emission control devices. The intentional disconnecting, bypassing, or disabling of such devices can result in fines and the loss of licenses and certifications.

EQUIPMENT AND SUPPLIES

- Vehicle with an air injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

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JOB SHEET 3

SERVICING AIR INJECTION SYSTEMS

Name ______________________________

OBJECTIVE 8 **Inspect, test, service, and replace pump unit components.**

INTRODUCTION

A pump type air injection system is never noise free. A positive displacement pump increases in pitch with any increase in engine rpm. However, a new pump might become quieter once it has been in service for about 500 hundred miles. Other causes of noise could be a loose pulley, loose mounting of the pump, an incorrectly adjusted belt, or a restricted hose. Pump units are usually installed as a new or rebuilt unit and are not repaired.

EQUIPMENT AND SUPPLIES

- Vehicle with an air injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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1020

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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EVALUATOR'S COMMENTS

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JOB SHEET 4

SERVICING AIR INJECTION SYSTEMS

Name ____

OBJECTIVE 9

Inspect, test, and replace vacuum-operated air control valves and vacuum hoses.

INTRODUCTION

An engine emissions vacuum schematic showing vacuum hose routings and the vacuum source for all the related emissions equipment is available on all vehicles, located on a decal under the hood. Appropriate service manuals contain other necessary information for the inspection, testing, and replacement of the valves and hoses of specific models.

Vacuum-operated air control valves and hoses can become loose, disconnected, broken, or worn. If a vacuum problem is suspected, the following guidelines should be helpful.

Guidelines:

- Inspect vacuum hoses for improper routing.
- Look for kinks, rips, or disconnections in the vacuum lines. Hoses with kinks can cut off the vacuum to a component and disable it.
- Check for vacuum hose wear near hot spots such as the exhaust manifold.
- Look for oil or transmission fluid on vacuum hose connections. Valves can become contaminated by these fluids.
- Inspect for damage to by-pass valves and broken nipples on vacuum control valves.

EQUIPMENT AND SUPPLIES

- Vehicle with an air injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

1022

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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EVALUATOR'S COMMENTS ______________________________

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1024

JOB SHEET 5

SERVICING AIR INJECTION SYSTEMS

Name ____

OBJECTIVE 10

Optional Activities/
Resources in
Instructor's Guide

Inspect and replace electrical/electronic-operated components and circuits.

INTRODUCTION

Computerized emission control systems use electrical/electronic sensors to measure various engine conditions and functions and then send this information to the engine computer which analyzes the information and makes the appropriate adjustments. Wiring diagrams should be consulted for the specific location of such electrical/electronic-operated components and circuits for the air injection system. Once located, the wiring should be checked for wear and damage. Wiring harnesses should be routed correctly, away from other electrical connections that might cause malfunctions. Wiring connections should be checked to make sure they are tight.

EQUIPMENT AND SUPPLIES

- Vehicle with an air injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

JOB
SHEET 6

SERVICING AIR INJECTION SYSTEMS

13

Name ______________________________

OBJECTIVE 11

Test the operation of an air injection system.

INTRODUCTION

Exhaust analyzers are used to measure the levels of hydrogen compounds (HC), carbon monoxide (CO), oxygen (O_2), and carbon dioxide (CO_2) in the exhaust to determine if the air injection system components are working properly. HC levels are measured in parts per million (ppm). An analyzer reading of 100 ppm means there are 100 parts of HC for every million parts of exhaust gas. A CO level reading of 1 percent means that 1 percent of the engine exhaust is made up of CO and the other 99 percent is made up of other substances. Oxygen level readings should be between .1 and 7 percent for the catalytic converter to function properly. CO_2 readings above 8 percent indicate that the catalytic converter is operating correctly. You should refer to the appropriate service manual for specifications of the allowable levels of HC and CO for the vehicle you are servicing.

EQUIPMENT AND SUPPLIES

- Vehicle with an air injection system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

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Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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EVALUATOR'S COMMENTS

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OBJECTIVE SHEET

SERVICING HEATED AIR INDUCTION SYSTEMS

14

INTRODUCTION

Found primarily on carbureted vehicles, the heated air induction system helps the engine warm up faster–particularly in cold weather. A failure in the heated air induction system causes an engine to run rough or hesitate when idling. Although a problem with the heated air induction system is the most common cause of these problems, it is often the last system checked. When functioning properly, the heated air induction system improves the performance of the vehicle. Since the early 1970s, most vehicles are built with a heated air induction system.

PREREQUISITE

Unit 13, "Servicing Air Injection Systems"

FOCUS ASSIGNMENTS

Reading Comprehension

- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language

- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition

- Use complete sentences

FOCUS ASSIGNMENTS

PREREADING:	Read Philip H. Abelson's editorial, "Automotive Fuel Efficiency," in *Science* magazine, September 1992, p. 1459. As you read, consider how manufacturers could make vehicles more fuel efficient by their design alone.
WRITING:	Write a short (one paragraph to one page) explanation of how manufacturers could make vehicles more fuel efficient and what you think the reaction would be from consumers.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. State the function of a heated air induction system.
2. Label the parts of a heated air induction system indicated on an illustration.
3. Describe the operation of a heated air induction system.
4. Test the operation of a heated air induction system. (Job Sheet 1)
5. Inspect and replace a heat stove shroud and hot air pipe of a heated air induction system. (Job Sheet 2)
6. Inspect, test, and replace sensors, diaphragms, the damper, and hoses of a heated air induction system. (Job Sheet 3)

INFORMATION SHEET

SERVICING HEATED AIR INDUCTION SYSTEMS

14

OBJECTIVE 1

State the function of a heated air induction system.

The heated air induction system improves engine performance and reduces emissions by decreasing engine warm-up time and keeping the temperature of the air entering the engine constant.

NOTE: Fuel vaporizes more completely when mixed with warm air, so heating the air allows the engine to run more efficiently and reduces emissions. Heating the air also prevents carburetor icing during warm-up.

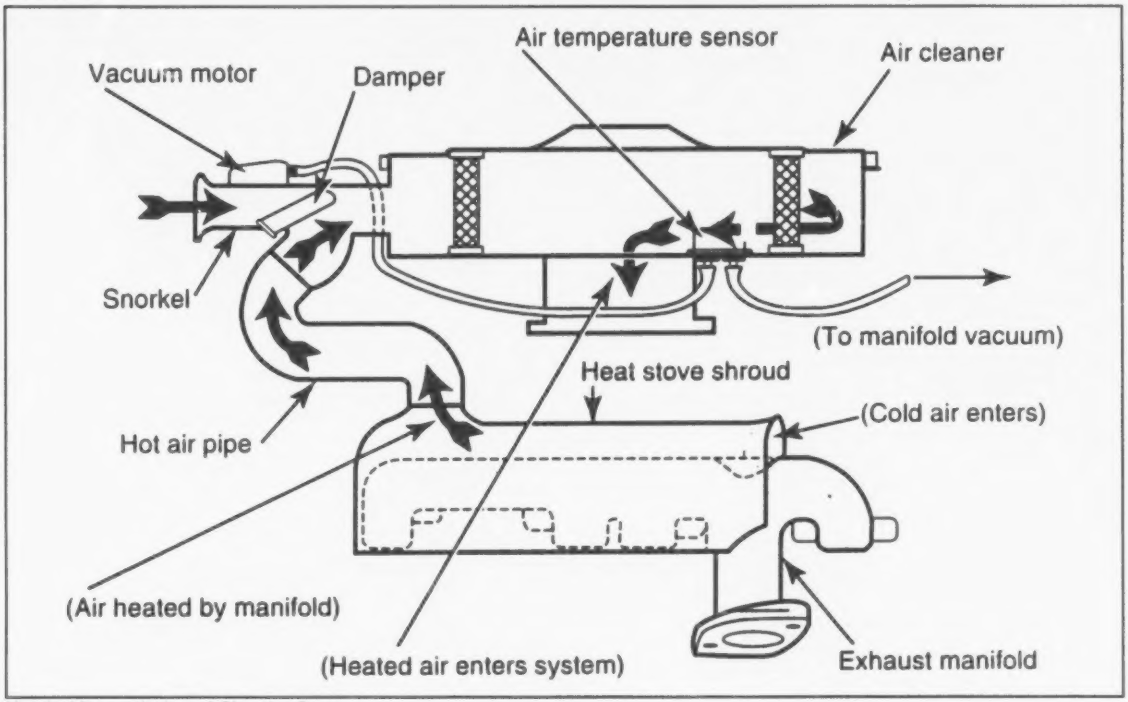
OBJECTIVE 2

Required Activities/
Resources
- Vehicle with a heated air induction system

Label the parts of a heated air induction system indicated on an illustration.

Look at a heated air induction system and its parts on an actual vehicle.

FIGURE 1


Air temperature sensor
Air cleaner
Vacuum motor
Damper
Snorkel
(To manifold vacuum)
Heat stove shroud
(Cold air enters)
Hot air pipe
(Air heated by manifold)
(Heated air enters system)
Exhaust manifold

Used with permission of Chrysler Corp.

NOTE: The air temperature sensor may be located anywhere in the air cleaner housing or in the snorkel.

OBJECTIVE 3

Describe the operation of a heated air induction system.

Required Activities/
Resources
– Transparency Master 1

Look at transparency 1 as your instructor explains how the different parts work together in the operation of a heated air induction system.

The air temperature sensor checks the temperature of air entering the air cleaner. If the air is too cool, the air temperature sensor activates a vacuum motor which pulls up the damper in the snorkel, allowing heated air coming through the heat stove shroud to blend with the cooler air.

☑ **NOTE:** Depending on the vehicle, the air temperature sensor either monitors air temperature and opens and closes the damper, maintaining a constant air temperature during engine operation, or it shuts off completely once the engine warms up.

OBJECTIVE 4

Complete Job Sheet 1.

OBJECTIVE 5

Complete Job Sheet 2.

OBJECTIVE 6

Complete Job Sheet 3.

JOB SHEET 1

SERVICING HEATED AIR INDUCTION SYSTEMS

14

Name ____

OBJECTIVE 4

Test the operation of a heated air induction system.

Required Activities/
Resources
– Explanation

Listen as your instructor explains why it is best to inspect and test this system on an annual basis.

INTRODUCTION

If the air temperature sensor does not activate the vacuum motor, there is no vacuum to operate the damper. A failure in the heated air induction system usually means the damper in the snorkel is staying in a down position. That means no heated air is being introduced into the air cleaner to mix with outside air. Although the driver may notice a lack of power in warm weather, in cold weather he or she may notice hesitation, surging, and stalling. The heated air induction system should be routinely checked annually just before cold weather begins.

To test the operation of the system, place a mirror at the end of the snorkel so you can watch the action of the damper. One simple test of the heated air induction system uses a hand vacuum pump to show you whether or not the damper is going up and down. If the damper is not operating properly, either the vacuum motor or the air temperature sensor is malfunctioning.

EQUIPMENT AND SUPPLIES

- Vehicle with a heated air induction system
- Appropriate service manual
- Mirror
- Hand vacuum pump

⚠ **NOTICE:** PROCEDURES VARY with the vehicle. ALWAYS CHECK THE PROCEDURE IN THE SERVICE MANUAL BEFORE BEGINNING ANY SERVICE OR REPAIR.

PROCEDURE

	Yes	No
1. Disconnect the hose between the vacuum motor and the air temperature sensor.	____	____

Research and Reference
- Use standard references

Functional Reading
- Interpret graphics and symbols
- Use content area vocabulary

Math Application
- Use English and metric measures

General Science
- Investigate/apply technology

Physical Science
- Investigate/apply physical laws

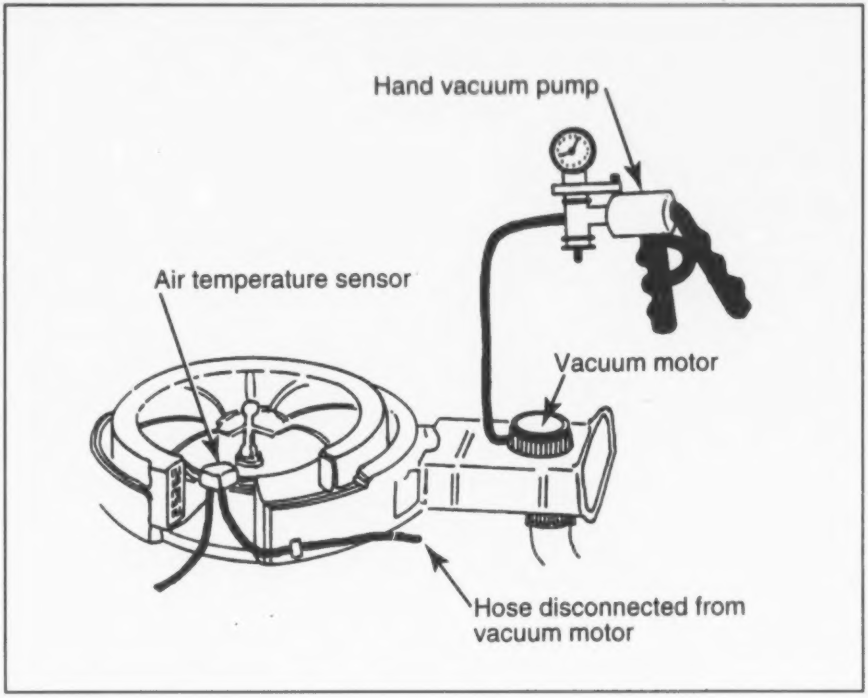
Cognitive Activities
- Transfer knowledge/training to new situations

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Yes No

2. Attach the hose from the hand vacuum pump to the vacuum motor. ____ ____

FIGURE 1



3. Squeeze the handle of the hand vacuum pump, and watch the gauge on the pump until 9 inches of vacuum has been applied. ____ ____

4. Place a mirror at the end of the snorkel, and watch the action of the damper. ____ ____

☑ **NOTE:** At the point where 9 inches of vacuum has been applied, the damper should move up to allow heated air from the hot air pump to enter the snorkel.

5. If the damper does not move up, it means the vacuum motor is not operating properly and it must be replaced. ____ ____

6. If the damper moves up, it means the vacuum motor is operating properly, but the air temperature sensor is faulty and must be replaced. ____ ____

7. Clean your work area, and return the equipment and supplies to proper storage or proceed to the next Job Sheet as directed by your instructor. Yes ____ No ____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

JOB SHEET 2

SERVICING HEATED AIR INDUCTION SYSTEMS

Name ______________________________

OBJECTIVE 5

Inspect and replace a heat stove shroud and hot air pipe of a heated air induction system.

INTRODUCTION

When the air temperature sensor senses that warmer air is needed for engine operation, the vacuum motor pulls up the damper, stopping the cold air from entering the air cleaner through the snorkel. This action opens the passageway to the heated air coming through the hot air pipe. Because the air from this source has been directed into a path through the heat stove shroud surrounding the exhaust manifold, it is considerably warmer. The heat stove shroud and hot air pipe should be inspected for damage annually before cold weather begins.

Guidelines:

- If the engine of the vehicle has been running, the heat stove shroud may be hot. Allow the heat stove shroud to cool before beginning your inspection.

- The heat stove shroud is made of metal, so inspect it for rust, cracks, and holes.

- The hot air pipe is sometimes metal, but it is usually heat resistant paper and metal foil which means it can tear or be easily damaged. Inspect it for tears, holes, and pinched or damaged sections.

  ☑ **NOTE:** This component is one of the most overlooked in the heated air induction system. It is, however, one of the most obvious sources of trouble.

- The top end of the hot air pipe fits over the extension at the bottom of the snorkel, and the bottom end fits over the extension from the heat stove shroud. Make sure these connections are tight.

EQUIPMENT AND SUPPLIES

- Vehicle with a heated air induction system
- Appropriate service manual
- Other equipment and supplies as required by the procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

- **4** **Skilled** – Can perform job with no additional training.
- **3** **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
- **2** **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
- **1** **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB
SHEET 3

SERVICING HEATED AIR INDUCTION SYSTEMS

Name ______________________________

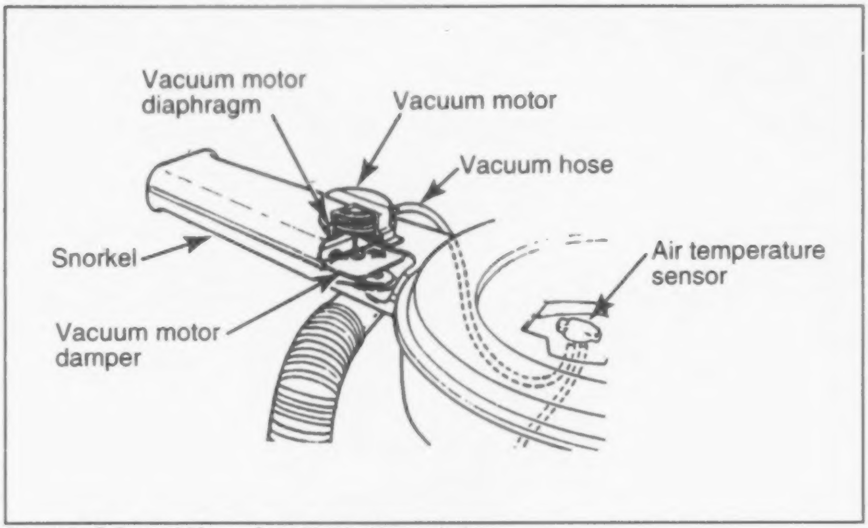
OBJECTIVE 6

Inspect, test, and replace sensors, diaphragms, the damper, and hoses of a heated air induction system.

INTRODUCTION

The air temperature sensor, the vacuum motor (including the diaphragm), and the vacuum hoses are all parts of the heated air induction system. Whenever a problem exists within the system, it is usually due to a failure of one of these components. (Figure 1)

FIGURE 1


Vacuum motor diaphragm
Vacuum motor
Vacuum hose
Snorkel
Air temperature sensor
Vacuum motor damper

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Guidelines:

- Temperature specifications for the air temperature sensor vary from one manufacturer to another, so check the specifications in the appropriate service manual before testing.

- Use a hand vacuum pump to help you test the vacuum motor and the air temperature sensor.

- If a problem is detected with the air temperature sensor, replace the entire sensor.
- If a problem is detected with the diaphragm or damper of the vacuum motor, replace the entire vacuum motor.

  ☑ **NOTE:** Some manufacturers do not supply replacement vacuum motors, and you must replace the whole air cleaner housing if the motor is bad.

- Inspect the vacuum hoses for cracks, damage, and loose connections. Hoses that are not connected properly or that are cracked may leak. Replace the hoses if necessary.

EQUIPMENT AND SUPPLIES

- Vehicle with a heated air induction system
- Appropriate service manual
- Other equipment and supplies as required by the procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications	4	3	2	1

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

____

____

____

OBJECTIVE SHEET

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

15

INTRODUCTION

Because cool air does not vaporize gasoline as well as warm air, manifold heat control systems are designed to heat the inlet air in a cold engine. Rapid heating is desirable because it provides quick fuel vaporization and more uniform fuel distribution to aid cold driveabilty. Because they increase fuel efficiency and reduce exhaust emissions, some type of manifold heat control system is used on all vehicles.

Primarily found in carbureted fuel delivery systems, most manifold heat control systems route heat from the exhaust manifold or the cooling system to the heating chamber surrounding the intake manifold. A temperature sensor is used to gauge the temperature of the intake manifold and monitor the on/off operation of the heat control system. The type of temperature sensor used depends upon the type of manifold heat control system. Because emissions research has not been shared since the 1969 Emission Control Act Consent Decree, manifold heat control systems and their components vary among automakers. An Engine Performance Technician needs to know how the manifold heat system works in order to diagnose, service, and maintain an efficient fuel delivery system and effective emissions control.

PREREQUISITE

Unit 14, "Servicing Heated Air Induction Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS

PREREADING:	Read Mark Rechtin's article, "Breathing Easy: California Leads Race to Quell Car Pollution," in *Automotive News*, September 21, 1993, pp. 152-153.
WRITING:	Write one or two paragraphs explaining how competition in emission research benefits our environment.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. State the function of a manifold heat control system.
2. Describe how the manifold heat control system usually achieves its function.
3. Name the types of manifold heat control systems shown in illustrations.
4. State the location where each type of manifold heat control system is installed.
5. Match the names of types of manifold heat control systems to descriptions of their operation.
6. Inspect, test, repair, and replace components of a manifold heat control system. (Job Sheet 1)
7. Test the operation of a manifold heat control system. (Job Sheet 2)
8. Inspect, service, and replace a manifold heat control valve. (Job Sheet 3)

INFORMATION SHEET

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

15

OBJECTIVE 1

State the function of a manifold heat control system.

A manifold heat control system increases fuel efficiency by heating the air-fuel mixture in a cold engine.

☑ **NOTE:** The heated air-fuel mixture vaporizes more evenly and allows more equal air-fuel distribution to each cylinder.

OBJECTIVE 2

Required Activities/
Resources
- Explanation
- Review

Describe how the manifold heat control system usually achieves its function.

Listen to your instructor's explanation of the operation of the heat chamber in a manifold heat control system.

Listen as your instructor reviews the function of the intake manifold.

The manifold heat control system warms the air-fuel mixture in the intake manifold by circulating hot exhaust gases in a special heat chamber constructed to surround the outside wall of the intake manifold.

☑ **NOTE:** Although this system is the most common way the manifold heat control systems achieves its function, one type achieves its purpose differently. (Figure 4)

OBJECTIVE 3

Name the types of manifold heat control systems shown in illustrations.

See the illustration after objective 5.

OBJECTIVE 4

State the location where each type of manifold heat control system is installed.

See the information after objective 5.

OBJECTIVE 5

Required Activities/
Resources
– Transparency
Masters 1-3

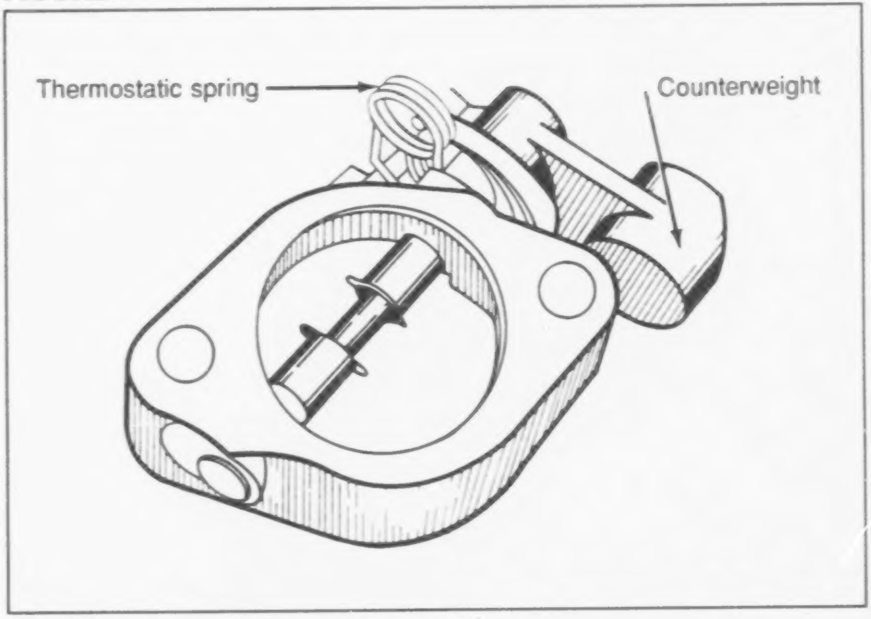
Match the names of types of manifold heat control systems with descriptions of their operation.

Look at transparencies 1-3 showing types of manifold heat control systems as your instructor discusses the location and operation of each.

WORDS YOU SHOULD KNOW	
exhaust	gases which flow from the cylinders into the exhaust manifold and eventually into the atmosphere through the exhaust system
intake manifold	the part of the engine which holds the air or air-fuel mixture just before it flows into the cylinders for combustion
exhaust manifold	the part of the engine that directs engine exhaust gases from the cylinders into the exhaust pipe and eventually into the atmosphere
heat chamber	the part of the engine, usually made of cast iron, which surrounds the intake manifold allowing space for exhaust gases to circulate

- **mechanical type heat control valve system**

FIGURE 1



Location: Between the exhaust manifold and the exhaust pipe.

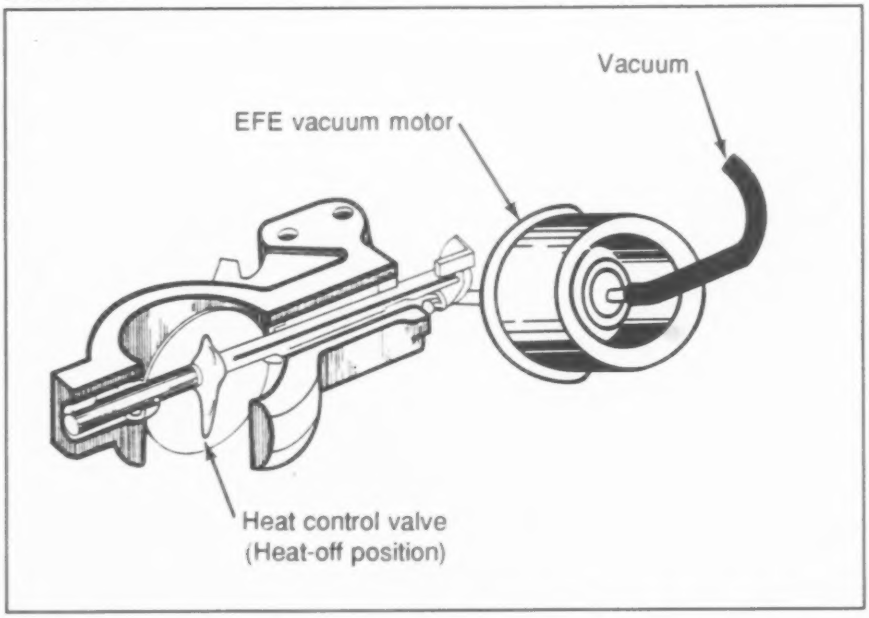
☑ **NOTE:** Refer to the service manual for the exact location.

Operation: Uses a large counterweight and a bimetal thermostatic spring to control the position of the heat control valve.

☑ **NOTE:** When the engine is cold the bimetal thermostatic spring is curled tight, forcing the heat control valve into the "heat on" position. As the engine warm ups, the exhaust heat causes the bimetal thermostatic spring to relax. With the spring relaxed, the exhaust gases can push the heat control valve into the "heat off" position. Mechanical type heat control valve systems are common in older vehicles. Always refer to the appropriate service manual for exact operation.

- **early fuel evaporation (EFE) vacuum type system with a thermal vacuum switch**

FIGURE 2



Location: Between the exhaust manifold and the exhaust pipe.

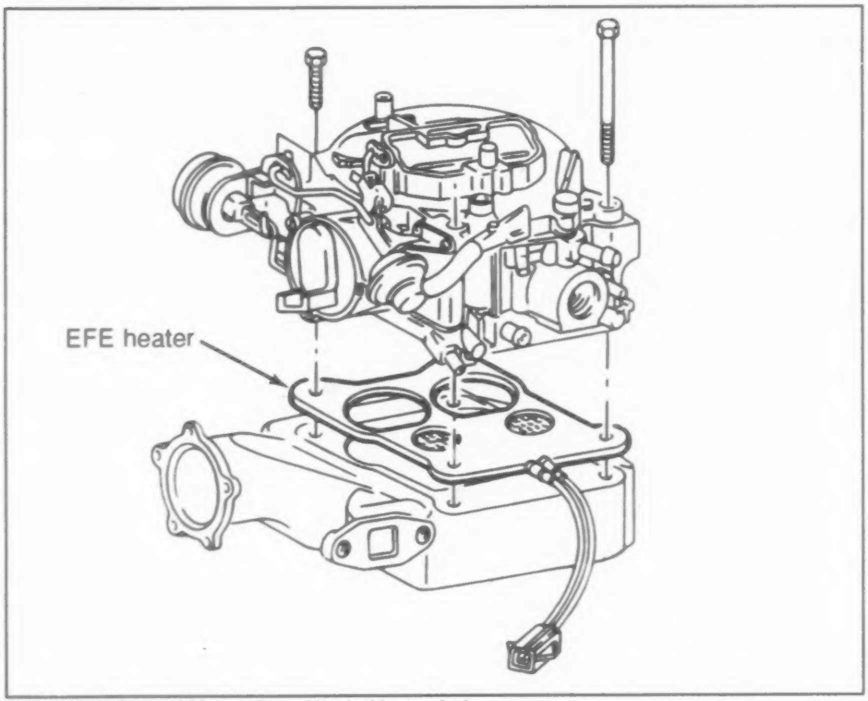
☑ **NOTE:** Refer to the service manual for the exact location.

Operation: Uses manifold vacuum and a vacuum motor controlled by a thermal vacuum switch to operate the heat control valve.

☑ **NOTE:** The thermal vacuum switch gauges the temperature of the intake manifold either mechanically or electrically and when the engine is cold admits manifold vacuum to the (EFE) vacuum motor. Intake manifold vacuum actuates the (EFE) vacuum motor through a vacuum hose and increases vacuum on the heat control valve until it quickly moves into the "heat on" position. When the engine is warm the thermal vacuum switch moves to restrict intake manifold vacuum on the (EFE) vacuum motor, shutting it off. Without vacuum the heat control valve moves back into the "heat off" position. This type of system is common in older (EFE) vacuum systems. Always refer to the appropriate service manual for exact operation.

- **early fuel evaporation (EFE) electrical grid type system**

FIGURE 3



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Location: Most often found mounted between the carburetor or the throttle body and the intake manifold.

☑ **NOTE:** Refer to the service manual for the exact location.

Operation: Uses an electrical heating element, or *grid* to heat the air-fuel mixture as it enters the intake manifold.

☑ **NOTE:** The engine computer employs sensors to monitor coolant temperature and engine rpm and then adjusts the grid temperature by switching the electrical current to the heating grid on or off. Used with both carbureted and fuel-injection systems, electrical grid type manifold systems do not have a heat control valve or a heat chamber. The grid, usually made of ceramic material, creates its own heat electrically. Always refer to the appropriate service manual for exact operation.

OBJECTIVE 6 **Complete Job Sheet 1.**

OBJECTIVE 7 **Complete Job Sheet 2.**

OBJECTIVE 8 **Complete Job Sheet 3.**

JOB SHEET 1

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

Name ____________________

OBJECTIVE 6

Required Activities/ Resources
- Vehicles with manifold heat control systems

Inspect, test, repair, and replace components of a manifold heat control system.

Watch as your instructor shows you the location of manifold heat control systems in several makes and models of vehicles.

INTRODUCTION

In a carbureted fuel delivery system, no matter how well mixed or vaporized the fuel mixture, its characteristics are changed as it passes through the intake manifold. Lower pressures and lower temperatures in the intake manifold will cause some of the vaporized fuel to condense, resulting in poor engine performance; therefore heat to the intake manifold is most needed when the manifold is cold. In order to effectively supply and regulate the amount of heat reaching the intake manifold, components of a manifold heat control system should be inspected as part of the routine emissions inspection - about every 30,000 miles.

If a component of the manifold heat control system is defective, it can usually be detected if the engine idles roughly, is slow to warm up, has flat spots on acceleration, or stalls. Because these same conditions can be caused by other problems in a vehicle, it is important that a complete diagnosis of the vehicle be done before focusing on the manifold heat control system as the primary cause of such problems.

If testing indicates a possible problem with the manifold heat control system, further inspection is needed. Testing the manifold heat control system involves inspecting the manifold for cracks or leaks in the heat control valve, exhaust and intake manifold floor, and heating chamber. Because any vehicle's manifold heat control system depends on properly functioning temperature sensors for best performance testing may involve inspecting, repairing or replacing a temperature sensor. Some vehicles will have two or more temperature sensors that monitor engine temperature and regulate the manifold heat control system. Testing the manifold heat control system can involve testing the intake manifold for sufficient vacuum. Refer to the appropriate service manual for type, location, and operation of the manifold heat control system.

Guidelines

- Refer to the appropriate manifold heat control system diagnosis chart, and drive the vehicle for a road test, checking for rough idle, engine stalls, flat spots, and other conditions described in the diagnosis chart.

- Perform a physical and visual inspection of the heat control system. Components you should inspect will include hoses, valves, the metal parts of the manifold and heat chamber, and thermostatic sensors that regulate the heat control system.

- Testing a heat control valve is a matter of making sure the valve moves freely. On a warm engine you should be able to move it by hand to see if it works.

- The most common problem with a manifold heat control system is a heat control valve stuck in the "heat on" position. This causes carbon build-up and possible cracking of the intake manifold floor. The valve can be loosened by hand or by gently tapping on it with a hammer.

- Inspect all parts of manifold heating control system for wear, damage, and binding including linkage, rubber hoses, and gaskets.

- Remove any defective parts that cannot be repaired, and replace them as directed by the appropriate service manual.

- At the factory, exhaust manifolds are usually bolted to the head with no gaskets because the machined surfaces are perfectly flat. In service, replacement gaskets are sometimes needed. Check for flat surfaces before replacing with gaskets.

- Do not remove the exhaust manifold when the engine is hot as it is possible it may warp.

EQUIPMENT AND SUPPLIES

- Vehicle (preferably with a carbureted fuel delivery system)
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB
SHEET 2

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

15

Name ______________________________

OBJECTIVE 7

Test the operation of a manifold heat control system.

INTRODUCTION

Testing the manifold heat control system is a matter of making sure the intake manifold is receiving sufficient heated air-fuel mixture during cold engine start up. In making such a test, refer to the appropriate manifold heat control systems diagnosis chart, and drive the vehicle for a road test, checking for rough idle, engine stalls, flat spots, and other conditions described in the diagnosis chart.

EQUIPMENT AND SUPPLIES

- Vehicle (preferably with a carbureted fuel delivery system)
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications	4	3	2	1

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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EVALUATOR'S COMMENTS

JOB
SHEET 3

SERVICING MANIFOLD HEAT CONTROL SYSTEMS

15

Name ____

OBJECTIVE 8

Inspect, service, and replace a manifold heat control valve.

Required Activities/
Resources
– Heat control valves in vehicles

Watch as your instructor shows you the location of a heat control valve in several makes and models of vehicles.

INTRODUCTION

Many heat control valves have a tendency to rust in position due to the acids and high temperature of exhaust gases. In order to maintain better engine performance, manifold heat control systems should be inspected at routine emission inspections and serviced when warranted. To inspect and service a manifold heat control valve you will first have to remove any major components that prevent access to the valve.

Guidelines:

- Do not remove the exhaust manifold when the engine is hot as it is possible it may warp.
- At the factory, exhaust manifolds are usually bolted to the head with no gaskets because the machined surfaces are perfectly flat. In service, replacement gaskets are usually needed. Check for flat surfaces before replacing with gaskets.
- When you inspect the heat control valve, make sure the valve moves freely.
- Some heat control valves can be repaired while others must be replaced. Always refer to the appropriate service manual.

EQUIPMENT AND SUPPLIES

- Vehicle (preferably with a carbureted fuel delivery system)
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

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Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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EVALUATOR'S COMMENTS ______________________________

____

____

OBJECTIVE
SHEET

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

INTRODUCTION

A vehicle has a network of interrelated systems and parts. A change in any part or system that affects performance and driveability also affects exhaust emissions. For example, the air-fuel mixture can affect ignition timing and engine performance. This, in turn, can change the amount of pollutants emitted by a vehicle. Therefore, emission control devices are an integral part of total vehicle operation and are included as part of an overall group of vehicle systems.

Before emission standards, vehicles used vented gas tank caps which allowed fuel vapors to escape into the atmosphere. Since the early 1970s, modern vehicles have used a fuel vapor control system which prevents this source of air pollution. Manufacturers use various names for this system: evaporative control system (ECS), evaporative emission control (EEC), vehicle vapor recovery (VVR), and vapor saver system (VSS).

PREREQUISITE

Unit 15, "Servicing Manifold Heat Control Systems"

FOCUS ASSIGNMENTS

Reading Comprehension
- Gain factual information
- Analyze cause and effect
- Draw conclusions

Language
- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition
- Use complete sentences

FOCUS ASSIGNMENTS	
PREREADING:	Read about how domestic vehicles are being equipped with smaller, more efficient, emission-improved engines in Dan McCosh's article, "Auto Tech 1994 — Power for the Future," in *Popular Science* magazine, October 1993, pp. 84-87, 118. Pay special attention to the improvement of emission control on these smaller engines.
WRITING:	Write a one page summary of the article, telling how engines have improved over pre-emission control engines, why engines are being redesigned, and the regulations responsible for these changes.

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment Sheet and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. State the function of a fuel vapor control system.
2. Label the parts of a fuel vapor control system indicated on an illustration.
3. Match the names of the parts of a fuel vapor control system to descriptions of their functions.
4. Describe the operation of a fuel vapor control system.
5. Test the operation of a fuel vapor control system. (Job Sheet 1)
6. Inspect, test, and replace thermal, vacuum, and electrical controls of a fuel vapor control system. (Job Sheet 2)
7. Inspect, service, and replace the components of a fuel vapor control system. (Job Sheet 3)
8. Diagnose engine mechanical, ignition, fuel, and emission control problems with an exhaust gas analyzer. (Assignment Sheet)

INFORMATION SHEET

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

OBJECTIVE 1

Optional Activities/ Resources in Instructor's Guide

State the function of a fuel vapor control system.

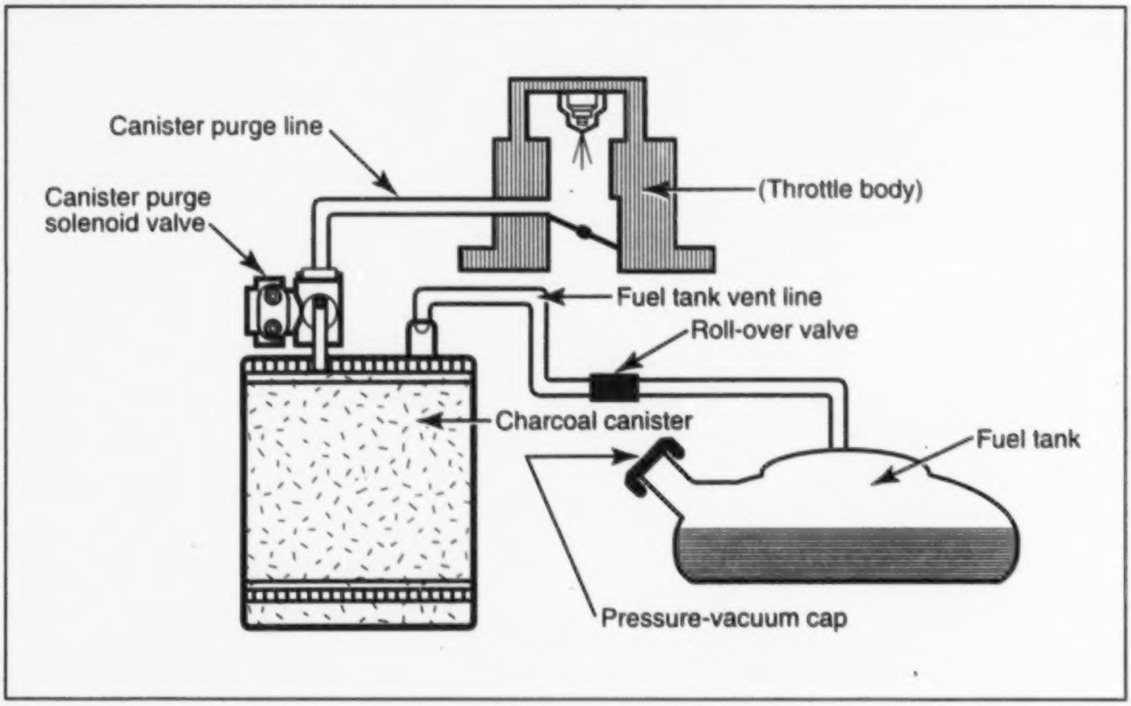
WORDS YOU SHOULD KNOW	
evaporation	a procedure in which liquid is turned into vapor
vapor	a substance in a gaseous state

A fuel vapor control system prevents pollution and increases vehicle fuel economy by preventing fuel vapors from escaping directly into the atmosphere.

OBJECTIVE 2

Label the parts of a fuel vapor control system indicated on an illustration.

FIGURE 1


Canister purge line
Canister purge solenoid valve
(Throttle body)
Fuel tank vent line
Roll-over valve
Charcoal canister
Fuel tank
Pressure-vacuum cap

1061

☑ **NOTE:** Figure 1 shows a fuel vapor control system on a vehicle with a carbureted engine.

OBJECTIVE 3

Required Activities/
Resources
- Transparency Master 1
- Fuel vapor control system parts

Match the names of the parts of a fuel vapor control system to descriptions of their functions.

Look at the transparency as your instructor explains the functions of the parts of a fuel vapor control system.

Examine actual fuel vapor control system parts.

WORDS YOU SHOULD KNOW	
adsorb	the adhesion of a very thin layer of gas or liquid to a solid

- **canister purge line** — carries stored fuel vapors from the charcoal canister into the engine intake manifold

  ☑ **NOTE:** When the engine is started, vacuum from the intake manifold causes fresh outside air to pass through the charcoal canister, carrying the vapor through the canister purge line into the intake manifold where it becomes a part of the air-fuel mixture burned in the engine cylinders.

- **canister purge solenoid valve** — responds to the engine computer's direction to open or close the canister purge line

- **charcoal canister** — stores fuel vapors from the fuel tank and/or the intake manifold

  ☑ **NOTE:** The charcoal canister is made of plastic or metal and is located in or near the engine compartment. It is filled with activated charcoal granules which adsorb the fuel vapors from the carburetor and fuel tank. The fuel vapors are always stored as a vapor, never as a liquid.

- **fuel tank** — holds the fuel supply for the vehicle

- **fuel tank vent line** — carries fuel vapors from the fuel tank into the charcoal canister

- **pressure-vacuum filler cap** — prevents fuel vapors from the fuel tank from entering the atmosphere

☑ **NOTE:** Any substance expands when it is heated. This is particularly true of liquids and gases. This type of gas tank cap contains pressure and vacuum valves that will open under extreme pressure or vacuum. However, if the fuel vapors expand normally, the pressure of the gases in the fuel tank will force the fuel vapors out the fuel tank vent line instead of the gas tank cap.

- **roll-over valve** — prevents liquid fuel from entering the fuel vent line if the vehicle is turned upside down

  ☑ **NOTE:** The valve contains a metal ball or plunger valve that blocks the fuel tank vent line in the event the vehicle is turned over.

OBJECTIVE 4

Describe the operation of a fuel vapor control system.

When the engine is turned off, fuel vapors from the intake manifold and the fuel tank flow into the charcoal canister where they are stored. When the engine is started, the vacuum in the intake manifold draws fresh air through the charcoal canister, carrying the stored fuel vapors into the intake manifold where they are used as part of the air-fuel mixture burned by the engine.

OBJECTIVE 5

Complete Job Sheet 1.

OBJECTIVE 6

Complete Job Sheet 2.

OBJECTIVE 7

Complete Job Sheet 3.

OBJECTIVE 8

Complete the Assignment Sheet.

ASSIGNMENT SHEET

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

Name ______________________________ Score __________

OBJECTIVE 8

Diagnose engine mechanical, ignition, fuel, and emission control problems with an exhaust gas analyzer.

INTRODUCTION

Optional Activities/ Resources in Instructor's Guide

A 4-gas analyzer measures the content of various gases in the exhaust stream. The analyzer can either be a part of the engine computer analyzer or a stand-alone unit. Often the analyzer probe is placed in the tail pipe, however, the procedure for operating the analyzer will vary according to the type of analyzer and the vehicle being checked. You should always follow the operating instructions for the analyzer you are using. Problems with pollution control systems can be particularly difficult to diagnose. It is best to follow the specific procedures outlined in the service manual. Use of a 4-gas analyzer is often required.

EQUIPMENT AND SUPPLIES

- Handouts 1-6, Unit 16

INSTRUCTIONS

Reading Comprehension
- Draw conclusions

Research and Reference
- Use in-book reference tools

Functional Reading
- Use content area vocabulary

General Science
- Investigate/apply technology

- Draw conclusions
- Transfer knowledge/training to new situations

Use the Handouts above to help you complete this Assignment Sheet. Read each of the following questions carefully, then select the answer for each that is most correct. Write the letter of the correct answer in the blank.

____ 1. A vehicle has detonation and an exhaust gas test shows that it has low percentage of carbon monoxide. Technician A says that the cause may be a loose PCV valve. Technician B says that if it is a loose PCV valve, the correct action to take would be to tighten the valve. Who is right?

A. Technician A
B. Technician B
C. Neither Technician A nor Technician B
D. Both Technician A and Technician B

____ 2. What exhaust gas is the best indicator of a malfunction in the components that control the air-fuel mixture?

A. Oxygen
B. Carbon Monoxide
C. Carbon Dioxide
D. Hydrocarbon

Job Acquisition/ Development
- Master specific job task/procedure

____ 3. A vehicle without a catalytic converter registers a HC level of 750 at 2500 rpm. Which of the following conditions most likely exists?

A. The air-fuel mixture is rich.
B. The air-fuel mixture is lean.
C. The air-fuel mixture is lean and causing the engine to misfire.
D. The readings are normal -- there are no adverse conditions.

____ 4. Which of the following emission control systems is disabled during most 4-gas analyzer tests?

A. Cold start enrichment system
B. Positive crankcase ventilation (PCV) system
C. Exhaust gas recirculation system
D. Air injection system

____ 5. The exhaust gas analysis on a vehicle with poor gas mileage shows that the oxygen content of the exhaust is low. What is the easiest corrective action the technician could try?

A. Use a gasoline with a higher octane
B. Replace air cleaner
C. Replace the fuel pump
C. Replace the fuel regulator

____ 6. A vehicle with a catalytic converter has a rough idle after warmup. When an exhaust analysis is made at idle, the HC is at 275 ppm, the carbon monoxide is at 1.27%, the CO_2 at 7%, and the oxygen at .04%. Technician A says that the problem could be a defective cold start enrichment system. Technician B says it could be a faulty purge valve. Who is right?

A. Technician A
B. Technician B
C. Neither Technician A nor Technician B
D. Both Technician A and Technician B

____ 7. The combustion ratio for a gasoline-powered internal combustion engine is 14.7 : 1. This ratio represents

A. One pound of fuel for every 14.7 pounds of oxygen
B. One pound of oxygen for every 14.7 pounds of fuel
C. One pound of fuel for every 14.7 pounds of air
D. One pound of additive for every 14.7 pounds of gasoline

____ 8. The owner of a newer vehicle complains of poor fuel mileage, but the vehicle has no other symptoms. Using the 4-gas analyzer, what type of problem would you expect?

A. A problem with a system influencing the air-fuel. ratio
B. An problem with the fuel vapor control system
C. A carburetor problem
D. A problem with the EGR system

____ 9. If an air-fuel mixture is too rich, what does it have too much of?

A. Air
B. Fuel
C. Exhaust emissions
D. Oxygen

____ 10. Technician A says that oxygenates are added to gasoline to help vehicle performance in cold months. Technician B says that the only difference between gasoline with and gasoline without oxygenates is that the gasoline with oxygenates vaporizes more quickly. Who is right?

A. Technician A
B. Technician B
C. Neither Technician A nor Technician B
D. Both Technician A and Technician B

____ 11. If the air injection system is disabled, what would you expect to happen to the hydrocarbon level of the exhaust after the vehicle is warmed up and running above idle?

A. It would go up.
B. It would go down.
C. It would stay the same.
D. It would not register on the 4-gas analyzer.

____ 12. The carbon dioxide reading on a vehicle with a catalytic converter, taken at idle, is 4%. What would you expect the oxygen level to be?

A. Too high
B. Too low
C. Either A and B
D. There is no way to tell from the carbon dioxide level.

_____ 13. What additional gas does the 5-gas analyzer test for?

A. Oxygenates
B. Nitrogen oxides
C. Methanol
D. Sulfur dioxide

_____ 14. To indicate a vehicle is running well, the carbon dioxide level should be

A. 14.7%
B. Above 11%
C. Below 10%
D. Higher than the percentage of oxygen.

_____ 15. What two controls affect the amount of oxygen in the exhaust?

A. ______________________________

B. ______________________________

JOB SHEET 1

SERVICING FUEL VAPOR CONTROL SYSTEMS

16

Name ______________________________

OBJECTIVE 5

Test the operation of a fuel vapor control system.

INTRODUCTION

Optional Activities/ Resources in Instructor's Guide

Although different manufacturers have different names for their systems, they are all very similar in operation. Fuel vapors from the fuel tank and/or the intake manifold are routed to and stored in the charcoal canister. When the vehicle is restarted, vapors are drawn into the intake manifold and from there to the engine cylinders.

Plugged or gasoline-soaked charcoal canisters, incorrect connection of components, faulty purge valves, line obstructions, and improper bowl vent operation can produce excessive pressure in the fuel tank, causing driveability problems often mistaken for fuel system problems. Symptoms include a rough idle, flooding, increased exhaust emissions, poor fuel economy, or fuel odor in the passenger compartment. Gasoline vapors noticeable during hard cornering may indicate faulty operation of a vapor/liquid fuel separator on the fuel tank.

Consult the appropriate service manual for the correct procedures for testing the operation of these parts.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel vapor control system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
2 **Limited Skill** – Has performed job during training program; additional training is required to develop skill.
1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

JOB SHEET 2 — SERVICING FUEL VAPOR CONTROL SYSTEMS 16

Name ______________________________

OBJECTIVE 6

Inspect, test, and replace thermal, vacuum, and electrical controls of a fuel vapor control system.

WORDS YOU SHOULD KNOW	
purge	to clean or purify. Clearing the stored fuel vapors from the charcoal canister is called purging. Running the engine removes or purges the vapor from the canister.

INTRODUCTION

Charcoal canister purging varies with the make and model of the vehicle. In some models, a fixed restriction allows constant purging whenever there is manifold vacuum. This additional vapor in the intake manifold while the engine is cold or at an idle can produce problems such as a rough running engine or increased emissions. In other models, purging is provided only at speeds above idle.

Usually, fuel vapor control systems have vacuum-operated purge valves that are closed until the manifold vacuum opens the vapor purge line from the canister to the engine. Some units incorporate a thermal-delay valve to prevent purging until the engine is above idle. Electronically controlled systems have a solenoid that controls vacuum to the purge valve and is activated only when the engine is warm and above idle.

Refer to the appropriate service manual for the correct location, identification, and procedures for testing and replacing these components.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel vapor control system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications	4	3	2	1
Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions
- Use content area vocabulary

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

4 **Skilled** – Can perform job with no additional training.
3 **Moderately Skilled** – Has performed job during training program; limited additional training may be required.
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EVALUATOR'S COMMENTS ______________________________

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JOB
SHEET 3

SERVICING
FUEL VAPOR CONTROL SYSTEMS

16

Name ______________________________

OBJECTIVE 7

Inspect, service, and replace the components of a fuel vapor control system.

INTRODUCTION

Many charcoal canisters have replaceable fresh-air filters while late model charcoal canisters may not and must be replaced as a unit. Some manufacturers recommend replacing the charcoal canister filter as a part of regular system service when the system air filter is replaced.

These filters are small foam discs located in the bottom of the charcoal canister. Usually the filters can be easily reached by releasing a spring clip under the bottom of the canister. On some vehicles, the canister cannot be easily reached and must be removed from the vehicle before the filter can be replaced. If liquid fuel is found in the charcoal canister, the purge control valve may not be working properly. Incorrectly installed lines and hoses will allow liquid fuel to collect in the hose, causing improper canister purging. This can create a fire hazard; lines and hoses must be replaced if faulty, insecure, or incorrectly installed.

Guidelines:

- Inspect all vacuum and fuel lines for hardening, cracks, breaks, kinks, and loose or disconnected connections.
- Inspect the vapor vent hose for correct installation. The hose must be routed in a continuous downward position.
- Examine rubber hoses for flexibility. They should not be stiff or hard.
- Replace defective lines one at a time to avoid misrouting.
- Replace all vapor and fuel lines with special vapor/fuel hose. Heater hose or vacuum tubing will cause rapid cracking, breaking, and leakage.

EQUIPMENT AND SUPPLIES

- Vehicle with a fuel vapor control system
- Appropriate service manual
- Other equipment and supplies as required by procedure

PROCEDURE

	Yes	No
Refer to the appropriate service manual for the make and model as equipped.	____	____

SKILL TEST RECORD

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Research and Reference
- Use standard references

Functional Reading
- Follow written instructions

General Science
- Investigate/apply technology

Job Acquisition/ Development
- Master specific job task/procedure
- Practice good work habits/attitudes

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

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Product meets manufacturer's adjustment specifications	4	3	2	1
Product includes proper components/materials	4	3	2	1
Product meets performance requirements	4	3	2	1
Product appearance meets industry standards	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Competency Profile, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

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1 **Unskilled** – Is familiar with process, but is unable to perform job.

EVALUATOR'S COMMENTS

ENGINE PERFORMANCE SPECIALIST

CIMC

READING SKILLS

UNITS OF INSTRUCTION	Reading Comprehension									Research and Reference								Functional Reading						Language		Composition					
	Gain factual information	Distinguish fact, opinion and inference	Recognize stereotyping and bias	Recognize propaganda	Analyze cause and effect	Draw conclusions	Make generalizations	React to written material	Apply word analysis techniques	Select useful resources	Locate resources	Find materials in library	Use standard references	Use in-book reference tools	Use audiovisual media	Use computer data base	Use magazines and newspapers	Interpret forms and records	Follow written instructions	Interpret graphics and symbols	Use content area vocabulary	Interpret abbreviations/acronyms	Read aloud	Use standard grammar and correct spelling, punctuation, and capitalization	State ideas clearly	Use complete sentences	Develop preliminary outline	Use topic sentences	Use introductory/closing paragraphs	Compose reports	Compose essays
Understanding Engine Fundamentals																															
Servicing Starting and Charging Systems						●							●	●					●	●	●										
Servicing Engine Cooling Systems						●								●					●	●											
Servicing Exhaust Systems						●							●	●					●	●	●	●									
Evaluating Engine Condition						●							●	●					●	●	●										
Understanding Engine Computer Controls													●						●												
Servicing Ignition Systems						●							●						●												
Servicing Fuel Delivery Systems						●							●	●					●												
Servicing Fuel Injection Systems						●								●					●		●										
Servicing Turbocharger Systems						●								●							●										
Servicing Positive Crankcase Ventilation													●							●	●	●									
Servicing Exhaust Gas Recirculation Systems													●						●			●									
Servicing Air Injection Systems													●						●												
Servicing Heated Air Induction Systems													●						●		●										
Servicing Manifold Heat Control Systems													●						●												
Servicing Vapor Control Systems						●								●					●		●										

CIMC BASIC SKILLS DOCUMENTATION

WRITING SKILLS

MATH SKILLS

osition					Research					Functional Writing							Operation and Calculation														Math Application											Data Analysis and Display								
Use introductory/closing paragraphs	Compose reports	Compose essays	Proofread and edit	Construct graphics and symbols	Take notes	Use notecards	Create bibliography	Use footnotes	Outline material	Complete forms and records	Write instructions	Write letters	Write job applications	Write resumes	Use word processing	Use computer graphics	Round off numbers	Estimate answers	Use scientific notations	Use exponential notations	Calculate with whole numbers	Calculate with fractions	Calculate with decimals	Convert whole numbers to fractions	Convert whole numbers to decimals	Solve numerical expressions	Solve formulae and equations	Obtain squares and square roots	Convert units of measure	Perform metric calculations	Solve word problems	Select/apply mathematical formula	Select/apply mathematical procedure	Use English and metric measures	Solve time/rate/distance problems	Solve ratio/proportion problems	Solve percent problems	Apply techniques of scaling	Apply algebra principles	Apply geometry principles	Apply trigonometry principles	Interpret charts and tables	Interpret graphs (type)	Collect /record data	Apply sampling techniques	Apply principles of probability	Construct charts and tables	Construct graphs	Calculate statistics	Interpret statistics
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ION MATRIX

ILLS

SCIENCE SKILLS

95-01122

Analysis Display						Functional Math														General Science									Life Science							Physical Science					Earth Science							
Apply principles of probability	Construct charts and tables	Construct graphs	Calculate statistics	Interpret statistics	Interpret blueprints/plans	Make measurements	Perform banking transactions	Make change	Solve practical problems	Calculate gross earnings	Solve income/expense problems	Prepare a budget	Calculate interest	Solve interest problems	Calculate sales tax	Determine income tax	Use calculator for computation	Use computer for computation	Use computer spreadsheets	Apply computing skills	Apply scientific method of inquiry	Conduct experiments	Investigate science ethics	Investigate science history	Investigate/apply economics in technology	Use scientific instruments	Investigate/apply technology	Collect specimens	Identify/classify living organisms	Investigate biological history of the earth	Investigate food chains, webs, pyramids	Investigate/apply principles of human development	Investigate/apply principles of genetics/heredity	Investigate/apply principles of anatomy/physiology	Investigate health issues	Analyze/classify matter	Investigate forms/changes of matter	Investigate forms/changes of energy	Investigate/apply chemical properties	Investigate/apply physical laws	Investigate physical characteristics of the earth	Investigate geological history of the earth	Investigate physical forces acting on the earth	Solve problems of longitude, latitude, and time zones	Investigate conservation of physical resources	Investigate conservation of living resources	Investigate issues of environmental impact	Apply science principles to environmental issues
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CIMC

ORAL COMMUNICATION SKILLS

INTERP.

UNITS OF INSTRUCTION

	Oral Presentation									Listening			
	Make informative presentations	Make persuasive presentations	Present personal opinion/viewpoint	Use good speaking techniques	Select/use words effectively	Use effective body language	Present appropriate appearance	Integrate audio and/or visual materials in oral presentations	Adapt presentation to specific audience	Apply active listening skills	Distinguish fact, opinion, and inference	Draw conclusions/make generalizations	Analyze/identify point of view
Understanding Engine Fundamentals													
Servicing Starting and Charging Systems													
Servicing Engine Cooling Systems													
Servicing Exhaust Systems													
Evaluating Engine Condition													
Understanding Engine Computer Controls													
Servicing Ignition Systems													
Servicing Fuel Delivery Systems													
Servicing Fuel Injection Systems													
Servicing Turbocharger Systems													
Servicing Positive Crankcase Ventilation													
Servicing Exhaust Gas Recirculation Systems													
Servicing Air Injection Systems													
Servicing Heated Air Induction Systems													
Servicing Manifold Heat Control Systems													
Servicing Vapor Control Systems													
* Use this line for entering your state or local codes for graduation requirements or learner outcomes.													

	Interactive Communication										General Relating													
	Give/follow oral directions	Apply questioning techniques	Conduct/receive interviews	Analyze/apply nonverbal communication	Work effectively in a group	Communicate with clients/customers/patients	Communicate with co-workers	Communicate with supervisors	Communicate with professional colleagues/associates	Apply telephone etiquette	Investigate/apply communication process models	Analyze/apply nonverbal communication	Investigate/apply cross-cultural communication	Interact with co-workers	Interact with supervisors	Interact with clients/customers/patients	Interact with professional/colleagues/associates	Interact with family/friends	Participate in group activities	Participate in industrial relations/functions	Identify personal values/attitudes	Apply information to life experiences	Identify values/attitudes	Identify needs/drives
Understanding Engine Fundamentals																								
Servicing Starting and Charging Systems																								
Servicing Engine Cooling Systems																								
Servicing Exhaust Systems		●																						
Evaluating Engine Condition		●																						
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ERPERSONAL OR RELATING SKILLS																						CREATIVE THINKING/ PROBLEM SOLVING SKILLS																				EMPLOYAB.											
Teamwork Cooperation															Leadership Influence							Cognitive Activities																				Job Search Selection											
Identify values/attitudes	Identify needs/drives	Select/apply appropriate behavior	Investigate/identify personal styles	Investigate/identify group/corporate climate	Give/receive feedback	Identify hidden purposes	Investigate/apply group dynamics	Control undesirable/inappropriate behavior	Resolve conflicts	Clarify goals/objectives	Devise "win/win" situations	Build consensus	Generate ideas	Present point of view	Analyze/apply leadership styles	Analyze/apply management styles	Obtain confidence of others	Develop esteem in self/others	Persuade others	Analyze/apply motivation techniques	Provide positive coaching	Collect/record information	Identify critical elements/issues	Define a problem	Identify underlying causes	Apply a problem-solving model	Analyze/synthesize information	Identify/analyze underlying assumptions	Draw conclusions	Predict results/outcomes	Identify/evaluate consequences	Identify/develop alternatives	Evaluate alternatives	Select an alternative	Devise a solution	Create a finished product	Apply intuitive/creative thinking processes	Transfer knowledge/training to new situations	Apply new technology	Develop an action plan	Evaluate results/outcomes	Analyze personal occupational aptitudes/preferences	Investigate employment prospects of a career field/occupation	Investigate training requirements for a career field/occupation	Investigate benefits of a career field/occupation	Compare/evaluate career options	Develop personal career path	Locate appropriate jobs	Analyze duties/requirements/benefits of specific job	Master specific job task/procedure	Fill in job-related application	Write letter of application	Write personal resume
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YABILITY SKILLS

SOCIAL STUDIES SKILLS

Job Aquisition Development														Information Analysis						Social Studies Application										Functional Social Studies															
Master specific job task/procedure	Fill in job-related applications	Write letter of application	Write personal resume	Interview for a job	Apply business etiquette	Practice good work habits/attitudes	Develop good personal presentation	Develop self-confidence/esteem	Develop effective leadership	Deal effectively with supervisors	Deal effectively with co-workers	Deal effectively with professional colleagues/associates	Deal effectively with customers/clients	Collect/record data	Interpret graphical information	Construct graphical information	Interpret maps/globes	Interpret statistical information	Analyze/interpret demographic information	Investigate/apply U.S. history	Investigate/apply world history	Investigate/apply U.S. geography	Investigate/apply world geography	Investigate/apply principles of government/politics	Investigate/apply principles of economics	Investigate/apply principles of ethics	Investigate/apply principles of psychology	Investigate/apply principles of sociology	Investigate/apply cross-cultural studies	Practice responsible personal economics	Prepare a personal budget	Use credit responsibly	Practice good work ethics	Participate in industrial relations	Interact with people of different races/cultures	Investigate/participate in government	Investigate/apply American legal practices	Select/use sources of information on current events	Analyze current events	Analyze consumer issues	Analyze social issues	Analyze conservation/ecology issues	Analyze social impact of science/technology	Analyze economic impact of science/technology
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